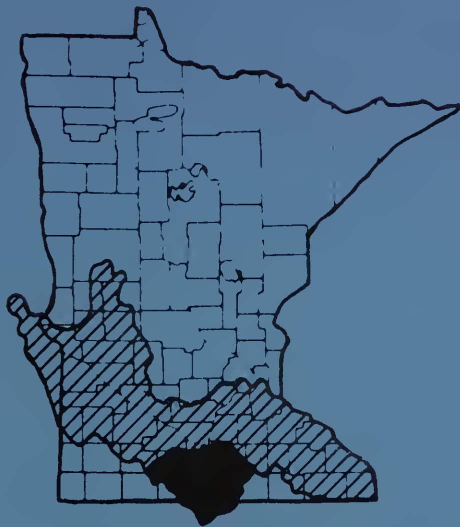
INVENTORY REPORT



BLUE EARTH RIVER SUBBASIN

STUDY AREA 1

of the

MINNESOTA RIVER BASIN

portion of the

SOUTHERN MINNESOTA RIVERS BASIN STUDY

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

FOREST SERVICE

ECONOMIC RESEARCH SERVICE

January 1972

To: All Participants in the Southern Minnesota Rivers Basin Study

Since July of 1970 the United States Department of Agriculture has been investigating the Blue Earth Subbasin of the Southern Minnesota Rivers Basin. Our team consisted of staff members from the Soil Conservation Service, Forest Service, and Economic Research Service.

When we began this study we promised the Soil and Water Conservation Commission, who are sponsors, and interested citizen groups, such as the Blue Earth Policy Committee, that we would submit a report of our findings about January of 1972. That time has come and we think it couldn't be more timely since a new Southern Minnesota Rivers Basin Commission has been organized and given authority by the State Legislature to use this inventory information and much more detailed information that is needed from us and other agencies to develop a river basin plan and guide its implementation.

We are pleased to submit the information we have gathered for the use of all participants in the Southern Minnesota Rivers Basin Study.

It is important to understand that this inventory report contains, for the most part, very preliminary data which is incomplete and will undoubtedly be changed in many ways as additional data is gathered. This is a working document. To distribute it to the general public would be premature and misleading.

During the next year we will be providing assistance to the Southern Minnesota Rivers Basin Commission. They are calling upon us and all other participating federal, state, and local agencies to more completely investigate the Blue Earth Subbasin. Some data gathering will also be initiated in other parts of the Southern Minnesota Rivers Basin.

Our thanks to those of you who helped us compile the information in this inventory. You can be assured of our continued dedication toward a truly coordinated local-state-federal effort to plan for the wise use of our natural resources in the State of Minnesota.

Harry M. Major for the United States Department of Agriculture - Field Advisory Committee

Harry Major, Chairman - Soil Conservation Service
Robert Lindahl - Forest Service
John Hostetler - Economic Research Service

BLUE EARTH RIVER SUBBASIN

INVENTORY REPORT

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I. SUMMARY

This Inventory Report of the Blue Earth Subbasin prepared by the Soil Conservation Service, Forest Service and Economic Research Service is the first step toward the creation of a comprehensive environmental conservation and development plan for the entire Southern Minnesota Rivers Basin.

The Southern Minnesota Rivers Basin Commission was established by the 1971 Minnesota State Legislature (H. F. No. 2041) to guide the creation and implementation of a comprehensive plan. The SMRB Commission decided to begin investigations in the Blue Earth River Subbasin and to complete an interim report on this portion of the basin by the Fall of 1972.

The objective of this inventory report is to present a collection of available data and the results of the investigations that have been made thus far.

The SMRB Commission can now direct appropriate Task Committees to review this inventory and make corrections where necessary, make additional investigations to obtain a great deal of necessary information, and present their subsequent findings to the Commission. When the Commission completes an interim report on the Blue Earth Subbasin, this Inventory Report will be obsolete.

The Blue Earth River Subbasin is a 3476 square mile area located in south central Minnesota and north central Iowa. 323 square miles of the subbasin are located in Iowa. All or part of 14 counties lie within the area. The subbasin includes all the watershed of the Blue Earth River which is a tributary of the Minnesota River. The Blue Earth River represents 20.5% of the drainage area of the Minnesota River.

Water and related land problems identified in the subbasin and the need for further studies include, but are not necessarily limited to, the following:

(1) Flooding is reported to cause damage to agricultural crops on about 28,000 acres of land.
(2) Improved drainage would benefit agricultural crop production on over 600,000 acres of cropland. Study is needed to more objectively answer questions about the effects of drainage on the environment.
(3) Erosion and sedimentation continue to reduce soil fertility, reduce stream channel capacities and reduce the aesthetic value of subbasin lakes and watercourses.
(4) Actual and potential effects of pollution on the quality of resources, natural and man made, need continued study. Many of the lakes are losing their value for recreation because of accelerated algae growth.

(5) Water supply shortages are not now apparent in the basin. Study is needed to accurately define future needs and the availability of a supply to meet the future needs.
(6) Approximately 30,000 acres of agricultural land have the characteristic of being droughty causing reduced crop yields in dry years.
(7) Fish, wildlife, and recreation development and overall environmental consideration cannot be fully investigated nor recommendations made by USDA agencies alone. Planning for a better environment is a highly complex matter which concerns everyone. Agencies other than those of the USDA who have the authority and knowledge to accomplish such planning are needed as input sources for the study.

The potentials for solving water and related land problems in the subbasin vary depending upon the problem being considered. Study has shown that upstream reservoirs cannot be used as an effective substitute for a large reservoir at the mouth of the Blue Earth River, to control flooding in Mankato or downstream on the Minnesota River. Upstream reservoirs, when properly located, can be effective in reducing upstream flooding in the subbasin.

Physical data on the 119 upstream reservoir sites studied can be found in Appendix 1. No attempt was made to select which sites might be desirable for such purposes as recreation, fish and wildlife, water supply, pollution abatement, and flood control. More study is needed by other agencies and SCS to identify site potentials by purpose and economic feasibility.

The potential exists for increased ground water use for irrigation if other cost factors can be justified. About 30,000 acres of droughty soils possibly could benefit from supplemental irrigation.

A good potential exists for the development of recreational and wildlife habitat corridors along most of the streams throughout the subbasin. Such land use is particularly well suited for areas subject to flooding. Increased recreational and wildlife land can be provided by corridors while intensive land use is restricted thus preventing the prospect of increasing flood damage.

Overall floodplain and land use management represents a potential for future wise land use through advance planning. Some counties in the basin have adopted zoning regulations. Floodplain regulations must be formulated to comply with recent state regulations.

Protection of the basins most important economic resource - the rich agricultural lands - offers an ongoing potential. Nearly 450,000 acres of cropland and pasture are adequately treated with soil loss - held to acceptable limits. However, nearly 1.5 million

acres of cropland and pasture need additional treatment to enhance soil productivity and reduce the polluting effects of excess soil loss.

It must be stressed again that a comprehensive plan for water and related land conservation and development requires a comprehensive study. The needed authority for such a study was created with the Southern Minnesota Rivers Basin Commission. A great amount of investigation and decision making is needed from the many agencies knowledgeable about the problems involved in fish and wildlife habitat, recreation development, water supply and quality needs, hydrologic considerations, power and navigation requirements, environmental questions and implementation recommendations.

II. INTRODUCTION

The 1971 Minnesota State Legislature passed an Act (H.F. No. 2041) which established the Southern Minnesota Rivers Basin Commission. Section 1 of the Act contains the following paragraph:

> Because of recurring flood damage, and because of other problems such as pollution, deficiencies in recreational and conservational opportunities, planning and projects, and deficiencies in planning and coordinating for economic growth, a Southern Minnesota Rivers Basin Commission is hereby created and charged with the obligation to guide the creation and implementation of a comprehensive environmental conservation and development plan for the Southern Minnesota Rivers Basin. The Commission may utilize all available scientific, economic, legal and social resources so as to make effective the purposes and policy of this act.

This Act of the State Legislature was a result of widespread expressions of need from local citizens, county officials, Soil and Water Conservation Districts, Watershed Districts, and elected state and federal government representatives.

Now, the Southern Minnesota Rivers Basin Commission is calling upon all agencies and organizations to pool their knowledge and resources to help develop a comprehensive environmental conservation and development plan for the basin. This is provided for in Section 3 of H.F. No. 2041 which states:

> In cooperation with all federal agencies, including but not limited to the United States Department of Agriculture, the Department of Interior and the U. S. Army Corps of Engineers, all state agencies, departments, and commissions, including but not limited to the Department of Natural Resources, Minnesota Geological Survey, Water Resources Board, State Planning Agency, Department of Highways, Soil and Water Conservation Commission, Pollution Control Agency, Department of Economic Development, Department of Agriculture, and the Institute of Agriculture of the University of Minnesota, and local governments and citizens within the basin, the commission shall initiate, coordinate and prepare its overall comprehensive environmental conservation and development plan. The Minnesota Soil and Water Conservation Commission and local Soil and Water Conservation Districts and Watershed Districts within the basin shall provide technical assistance to the commission in the creation and implementation of the plan.

The SMRB Commission has decided to begin investigations in the Blue Earth River Subbasin.

This Inventory Report, from the USDA Agencies, is a first step toward a complete comprehensive investigation of the Blue Earth River Subbasin. The report is to be used as resource information by the Commission and other participating agencies. The information is very preliminary and incomplete. Other participating agencies should identify and correct mistakes, provide missing information, and assist the Commission in preparing an interim comprehensive and environmental conservation and development report on the Blue Earth River Subbasin in 1972.

1. Why the Study is Needed

The Upper Mississippi Comprehensive River Basin Study identifies the Minnesota River Basin as a first priority sub-area for detailed survey recommendations to meet water and related land resource needs and potential for achieving conservation objectives. The sub-areas in which the more critical needs are apparent and which would contribute most to providing food and fiber needs in future periods, were included in this first priority.

The Blue Earth River Subbasin, as part of the Minnesota River Basin, showed greatest needs for study of water and related land resource use and strong local interest for such study. Therefore, it is being given first priority for investigation in the Southern Minnesota Rivers Basin Study in progress.

Because of the alternatives present in this subbasin for land and water development, additional study is needed to facilitate compromise on the competitive land and water uses. There are significant regional and national benefits which would be realized with construction of the floodwater control dam on the Blue Earth River as proposed by the U. S. Corps of Engineers. Study of additional alternatives are needed to fully evaluate the overall impact of such a proposal. Are there feasible alternatives which could achieve similar results with less costs? Are overall water and related land needs being viewed objectively with adequate attention given to social and environmental interests? It is questions such as these which involve elements of conflict that points to a need for continued evaluations to best meet the objective of good resource use.

2. Objectives and Nature of the Study

The Blue Earth River Subbasin is being carried out as a comprehensive water and land resource development study by both government and non-government groups. Overall objectives for the study are being formulated by the newly formed Southern Minnesota Rivers Basin Commission.

The Commission is directed in H. F. No. 2041 to plan for at least the following purposes:

(1) Control or alleviation of damages by flood waters
(2) Improvement of stream channels for handling of surface waters, navigation, and any other public purposes

(3) Reclaiming or filling of wet and overflowed lands
(4) Regulating the flow of streams and conserving the waters thereof
(5) Diverting or changing watercourses in whole or in part
(6) Providing and maintaining water quality and supply for municipal, domestic, industrial, recreational, agricultural, aesthetic, wildlife, fishery, or other public use
(7) Providing for sanitation and public health and regulating uses of streams, ditches, or watercourses for the purpose of disposing of waste and maintaining water quality
(8) Repair, improvement, relocation, modification, consolidation or abandonment in whole or in part of previously established public drainage systems within the territory
(9) Imposition of prevention or remedial measures for the control or alleviation of land and soil erosion and siltation of watercourses or bodies of water affected thereby
(10) Regulation of improvements and land development by abutting landowners of the beds, banks, and shores of lakes, streams, watercourses, and marshes by permit or otherwise in order to preserve the same beneficial use, such regulation to be in accordance with State Department of Natural Resource standards and criteria
(11) Regulation of construction of improvements on and prevention of encroachments in the flood plains of the rivers, and the lakes, marshes and streams of the basin, such regulation to be in accordance with State Department of Natural Resource standards and criteria

3. Description of the Study Area

The Southern Minnesota Rivers Basin is defined to include the area within the watersheds of rivers and streams tributary to the Minnesota River, and the areas within the watersheds of the rivers tributary to the Mississippi River on the westerly side of the Mississippi River in Minnesota south of its confluence with the Minnesota River. Figure 2.1 shows the area included in the Southern Minnesota Rivers Basin and the tentative delineation of study areas.

The Blue Earth River Subbasin was selected as Study Area I in the Southern Minnesota Rivers Basin. Figure 2.2 shows the area included in the Blue Earth River Subbasin.

TENTATIVE STUDY AREA DELINEATION
SOUTHERN MINNESOTA RIVERS BASIN

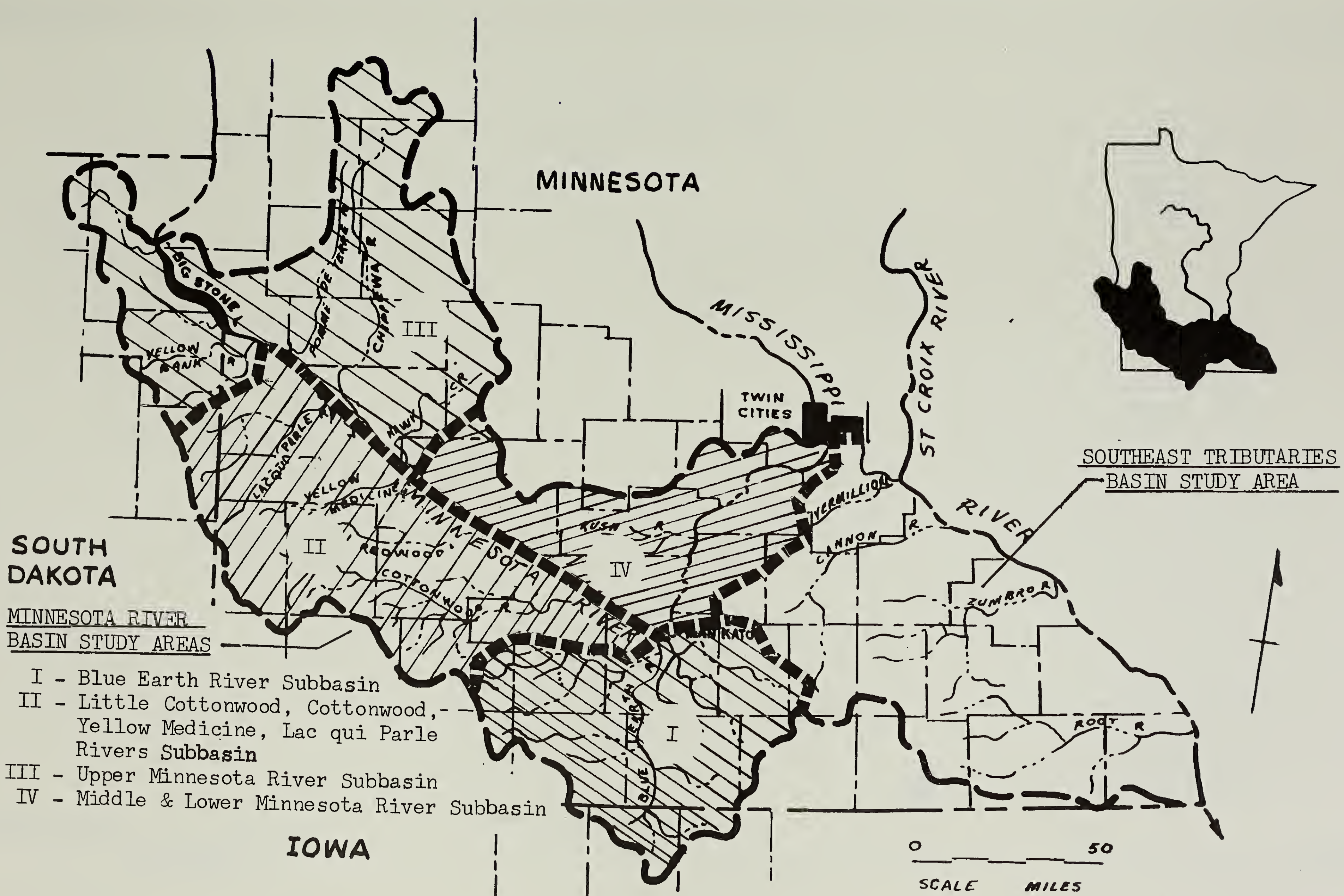


Figure 2.1

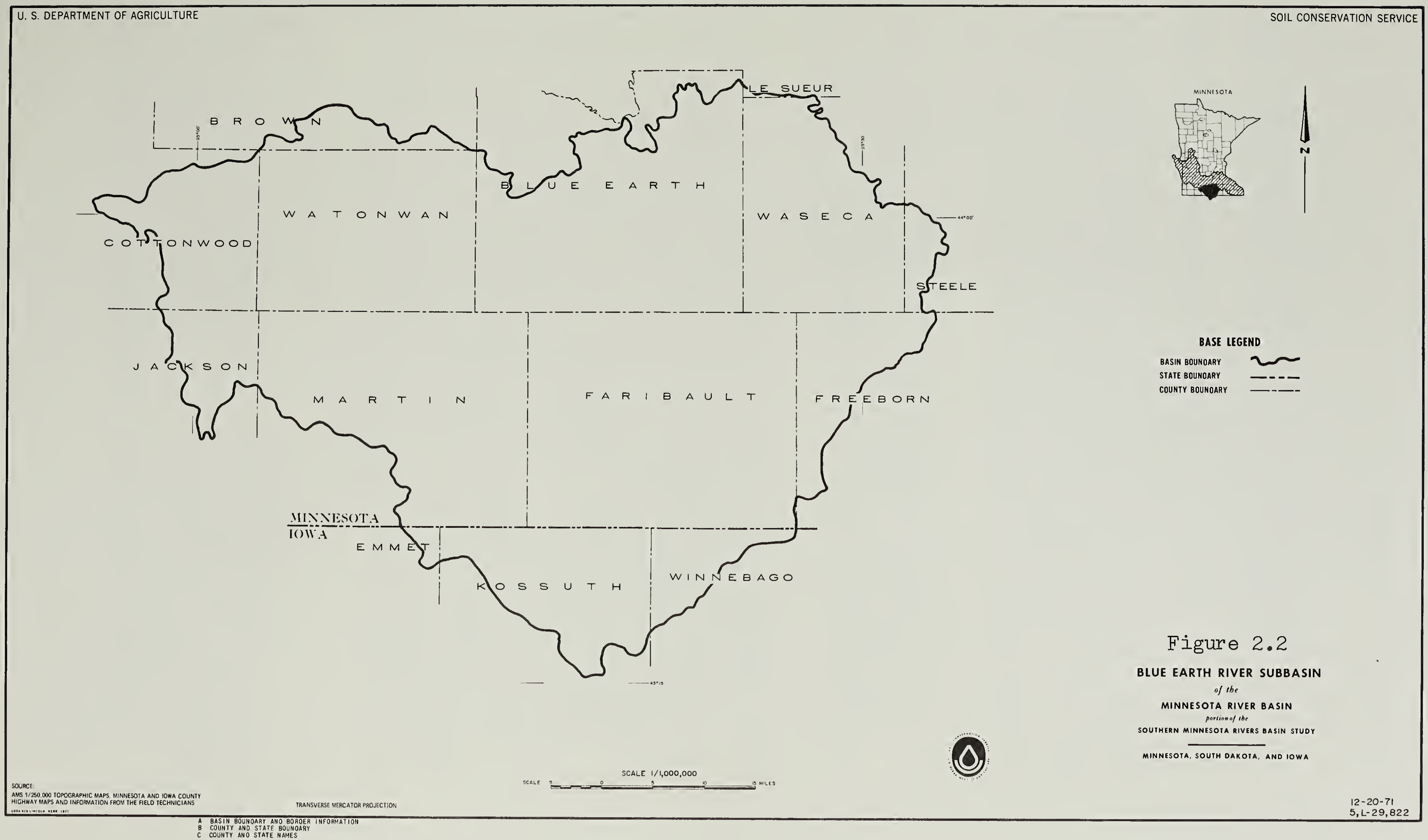


Figure 2.2
BLUE EARTH RIVER SUBBASIN
of the
MINNESOTA RIVER BASIN
portion of the
SOUTHERN MINNESOTA RIVERS BASIN STUDY

MINNESOTA, SOUTH DAKOTA, AND IOWA

4. Agencies Participating in the Study

The Southern Minnesota Rivers Basin Commission is asking for agency participation on Task Committees as designated in Table 2.1.

5. USDA Agency Authority and Participation

In June 1970, the USDA approved a request for an intensive river basin study in the Southern Minnesota Rivers Basin and funds were authorized for participation by the Soil Conservation Service, Forest Service, and Economic Research Service. This request came from the Minnesota State Soil and Water Conservation Commission. Many such requests are made of the U. S. Department of Agriculture each year with only a few of these being selected for authorization.

Participation of USDA is authorized under Section 6, Public Law 566, as amended. Section 6 authorizes the Secretary of Agriculture, in cooperation with other federal, state, and local agencies, to make investigations and surveys of the watersheds of rivers and other waterways as a basis for the development of coordinated programs.

A total of about $1.5 million of federal funds to support a staff representing about 90 man years of work is expected to be available for the USDA participation throughout the Southern Minnesota Rivers Basin study. These are medium figures which could decrease if state funding and participation is low and might increase if a high degree of state participation and leadership is provided. The establishment of the Southern Minnesota Rivers Basin Commission is a big step toward providing the type of state leadership and participation that is required. This type of study, which was formerly called a Type IV Study, is now appropriately called a cooperative river basin study. A cooperative study simply means that USDA agencies are cooperating with the state, and assisting, along with other state and federal agencies, in developing a detailed river basin plan. The state has requested our assistance and the state has the leadership responsibilities. We welcome the opportunity to follow the states' direction and assist in finding solutions to the problems which very obviously concern the people in southern Minnesota.

6. How the Inventory was Made

Efforts by the USDA agency staffs since June 1970 have resulted in the collection and interpretation of substantial basic information in the Blue Earth River Subbasin. It will help the users of this data to understand how this was accomplished. The USDA plans to use essentially the same procedures in other subbasins hopefully in partnership with state agencies and under the leadership of the Southern Minnesota Rivers Basin Commission.

Table 2.1

SUMMARY OF TASK COMMITTEE ASSIGNMENTS
SOUTHERN MINNESOTA RIVERS BASIN COOPERATIVE STUDY

AGENCY	TASK COMMITTEES																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Obj.	Review	Econ. Base	H&H	Water Supply	Water Qual.	Flood Plain	Nav.	Drain. & Irri.	Eros. S.L.T.	Rec.	F.& W.L.	Shore L. & L.R.	Power	Evt.	Ed. & Info.	Form.	Legal	Report
STATE																			
Soil & Water Cons. Comm.	(x)	(x)	x				x		x	x							x	x	x
State Planning Agency	x	x	x		x									(x)	(x)		(x)	x	(x)
Dept.of Natural Resources	x																		
Bureau of Inf.-Ed.		x	x													$\bar{x}$	x	x	x
Div.Wat.Soils & Min.		x	x	(x)	(x)		(x)	(x)	(x)				(x)				x	x	x
Div.Parks & Rec.		x	x			x		x			(x)	x	x				x	x	x
Div.Game & Fish		x	x			x		x	x	x	x	(x)	x				x	x	x
Div.Lands & Forestry		x	x			x				x	x	x	x				x	x	x
Dept.of Econ. Dev.	x	x	(x)		x			x			x		x	$\bar{x}$			x	x	x
Dept. of Highways		x	x	x													x	x	x
Pollution Control Ag.	x	x	x			(x)											x	x	x
Water Resources Bd.		x	x	x	x	x		x									x	x	x
Dept. of Health		x	x		x	x											x	x	x
Univ. of Minn.	$\bar{x}$	x	x	x	x	x	x		$\bar{x}$	(x)	$\bar{x}$				$\bar{x}$		x	x	x
Assoc.Minn.Counties		x	x		x			x			x		x				x	x	x
League of Minn. Mun.		x	x		x	x		x			x						x	x	x
Dept. of Agriculture		x	x						x								x	x	x
Attorney General		x	x														x	(x)	x
Geological Survey		x	x	x	x	x											x	x	x
Metropolitan Council		x	x					$\bar{x}$									x	x	x
Ag. Extension Service		x	x													(x)	x	x	x
FEDERAL																			
U.S.Soil Cons. Service	x	x	x	x		x	x		x	x	x	x	x				x	x	x
U.S.Forest Service		x	x			x				x	x		x				x	x	x
U.S.Economic Res.Serv.		x	x		x												x	x	x
Corps of Engineers	x	x	x	x		x	x	x		x	x		x	x			x	x	x
Fish & Wildlife Serv.		x	x								x	x	x				x	x	x
Bureau Outdoor Rec.		x	x								x		x				x	x	x
U.S.Geol. Survey		x	x	x	x	x	x			x							x	x	x
U.S.Weather Bureau		x	x	x													x	x	x
FWQA		x	x			x											x	x	x

(x) - Chairman Agency
$\bar{x}$ - Vice Chairman Agency

Work accomplished in the Blue Earth River Subbasin can be logically divided into two phases:

Phase I was the inventory and data collecting and scheduling phase. During this stage, schedules were developed, maps and other materials required to initiate field work were collected and prepared. Preliminary arrangements were made with USDA agency personnel and cooperating agencies for conducting the field work by basin staff members and field assistance by others. Existing reports and Conservation Needs Inventory data, as well as other information, were collected and studied.

As Phase I was initiated the USDA basin staff interviewed the SCS District Conservationist and others in each county and made a brief field reconnaissance. Questionnaires were distributed to County Commissioners and Soil and Water Conservation Districts to more closely determine local feelings of needs and problems.

Following this, the basin staff made a field reconnaissance of those watersheds selected as having significant problems and a need for some type of investigation. During Phase I, data and interview notes were recorded and summarized. The summary for each watershed described the area, the problems and needs, a judgment regarding potential development, and recommendations for additional study in Phase II.

Priorities of study were tentatively established for watersheds within the Blue Earth Subbasin during Phase I. The basis for selecting a priority watershed area was determined by local interest and by its apparent potential to be socially, physically and economically justified as an opportunity for development. Other factors considered were geographic distribution and the representative cross-section of problems and needs.

Recommendations for priority studies were presented to the Southern Minnesota Study Committee, chaired by the Soil and Water Conservation Commission. It will be the Committee's responsibility to establish priorities, as well as their overall duty to coordinate federal, state and local participation in the study.

Phase II involved detailed investigations in areas which have been given priority by the Study Committee. Table 2.2 shows the priority of study for these areas. Figure 2.3 is a map showing the general location and distribution of these study areas in the subbasin. SCS, ERS, and FS technicians are still collecting basic data that will be used to evaluate the selected areas. Further economic analysis will be conducted, including the modification and compilation of data to meet specific needs.

Field data has been collected on selected development needs that are not necessarily justified as project development under USDA authorities, but may have potential for development by other agencies or groups.

One of the functions of the USDA team is to prepare Watershed Investigation Reports and Watershed Evaluation Reports for specific problem areas. A Watershed Investigation Report is prepared if a watershed project is considered to be feasible under present P.L. 566 criteria. A Watershed Evaluation Report is prepared if a watershed project is not feasible under present P.L. 566 criteria, but may be feasible at a later date or feasible under another program. These reports will be completed as investigations progress.

Table 2.2

Priority of Study for Watershed Investigation Reports and Watershed Evaluation Reports, Blue Earth River Subbasin

Priority Group No. 1

(1) WIR - South Fork of the Watonwan River - Watershed No. 8e1-06,07,08,09
(2) WER - Maple River Watershed - Watershed No. 8e2-11
(3) WER - Dutch Creek Watershed - Part of Watershed No. 8e-15
(4) WER - Cobb and Little Cobb Watersheds - Watershed Nos. 8e2-06,07
(5) WER - Union Slough Watershed - Watershed No. 8e-06

Priority Group No. 2

(1) WER - Butterfield Creek Watershed - Watershed No. 8e1-02
(2) WER - Elm Creek Watershed - Watershed No. 8e-17
(3) WER - East Fork of the Blue Earth River - Watershed No. 8e-13

Figure 2.3
Location of Priority Study Areas

BLUE EARTH RIVER SUBBASIN
of the
MINNESOTA RIVER BASIN
portion of the
SOUTHERN MINNESOTA RIVERS BASIN STUDY

MINNESOTA, SOUTH DAKOTA, AND IOWA

A BASIN BOUNDARY AND BORDER INFORMATION
B COUNTY AND STATE BOUNDARY
C COUNTY AND STATE NAMES

III. NATURAL RESOURCES

Basic to the potential for development of water and related resource development is the endowment of physical resources. The climate, physiography, geology, soils, land use, water quantity and quality, fish and wildlife resources and the quality of the natural environment are factors which must be considered in planning resource development. Each is important and makes its unique contribution to the physical capacity and potential development of the subbasin. This chapter describes these resources.

1. Location

The Blue Earth River Subbasin is located in south central Minnesota and north central Iowa. The subbasin encompasses 3,476.4 square miles of which 3,153.0 square miles are in Minnesota and 323.4 square miles are in Iowa. All or parts of 11 counties in Minnesota and 3 counties in Iowa are included. The area by counties is shown in Table 3.1.

TABLE 3.1

Area by Counties
Blue Earth River Subbasin

State	County	Total Area in County	Area in Subbasin	Percent of Co. in Subbasin	Percent of Total Subbasin
Minnesota	Blue Earth	753.0	570.1	75.7	~~10.4~~ 16.4
	Brown	618.0	59.1	9.5	1.7
	Cottonwood	645.0	193.8	30.0	5.6
	Faribault	718.0	718.0	100.0	20.6
	Freeborn	718.0	152.3	21.2	4.4
	Jackson	717.0	84.8	11.8	2.4
	LeSueur	467.0	2.4	0.5	0.1
	Martin	727.0	554.3	76.2	15.9
	Steele	417.0	37.4	8.7	1.1
	Waseca	425.0	343.8	80.4	~~4.4~~ 9.9
	Watonwan	437.0	437.0	100.0	12.6
Iowa	Emmet	402.0	12.9	3.2	0.4
	Kossuth	979.0	237.8	24.3	6.8
	Winnebago	402.0	72.7	18.1	2.1
Total			3,476.4		100.0

The subbasin includes all of the area drained by the Blue Earth River which is a tributary of the Minnesota River. Figure 3.1 shows the location of the watersheds in the subbasin as designated by the SCS Conservation Needs Inventory. Table 3.2 lists the names of these watersheds by CNI number. The 3,476.4 square miles in the Blue Earth Subbasin is 20.5 percent of the Minnesota River Basin which encompasses 16,920 square miles.

2. Climate[1/]

The climate in the vicinity of the Blue Earth River Subbasin is continental, characterized by wide variations in temperature, ample rainfall for crops, and moderate snowfall. Meterological data for this area are available from a number of regular U. S. Weather Bureau stations in or near the subbasin. Five stations for which normals (averages for the period 1931-60) have been established plus two other stations were used in the analysis of temperatures and precipitation for the Blue Earth River Subbasin. The stations at Fairmont, Winnebago, and Waseca Experiment Station are the only ones in the subbasin for which normals have been established. The four stations located outside of the subbasin which were used include Albert Lea, North Mankato, and Windom in Minnesota and Forest City in Iowa. All have records of 36 years or longer.

A. Temperature

From the data published for the seven selected Weather Bureau stations, the mean monthly temperatures vary from 73° F in July to 15° in January and the mean annual temperature is 45.7° F. The extreme high temperature recorded in the subbasin was 109° F, observed at Fairmont on 3 August 1930, while the extreme low temperature recorded was -37° F on 5 January 1887 at Albert Lea, located about 10 miles east of the subbasin. The mean number of days between the last spring occurrence and first fall occurrence of 32° F is 151 days for the seven stations analyzed. Figure 3.2 shows the average monthly temperatures for the subbasin.

B. Precipitation

The mean annual precipitation for the seven Weather Bureau stations is 28.32 inches. The minimum annual precipitation recorded is 14.25 inches, occurring at Windom in 1910. The maximum, 46.93 inches, was observed at Forest City, Iowa in 1938. Of the total annual precipitation, about 66 percent normally occurs during the period May through September.

1/Data from Appendix B, Interim Survey Report on the Blue Earth River, Minnesota, St. Paul District, Corps of Engineers.

Figure 3.1
WATERSHED LOCATIONS
Study Area 1 - BLUE EARTH RIVER SUBBASIN
of the
MINNESOTA RIVER BASIN
portion of the
SOUTHERN MINNESOTA RIVERS BASIN STUDY

MINNESOTA, SOUTH DAKOTA, AND IOWA

SOURCE:
AMS 1/250,000 TOPOGRAPHIC MAPS, MINNESOTA AND IOWA COUNTY HIGHWAY MAPS AND INFORMATION FROM THE FIELD TECHNICIANS.

SCALE 1/500,000
SCALE 5 0 5 10 15 MILES

TRANSVERSE MERCATOR PROJECTION

1-3-72
5,0-29828

TABLE 3.2

WATERSHEDS IN THE BLUE EARTH SUBBASIN

CNI WATERSHED CODE NO.	NAME OF LOCAL WATERSHED	AREA SQ.MI.
BLUE EARTH RIVER - 8e		
Minn-UM-MINN-8e-01	D. D. #7	14.9
Minn-UM-MINN-8e-02 & 03	Blue Earth River	232.6
Minn-UM-MINN-8e-04	D. D. #80	25.0
Minn-UM-MINN-8e-05	D. D. #90	23.8
Minn-UM-MINN-8e-06	Union Slough	57.2
Minn-UM-MINN-8e-07	D. D. #60	51.3
Minn-UM-MINN-8e-08	West Fork Blue Earth River	52.2
Minn-UM-MINN-8e-09	Coon Creek	81.2
Minn-UM-MINN-8e-10	Badger Creek	83.5
Minn-UM-MINN-8e-11	Brush Creek	47.3
Minn-UM-MINN-8e-12	Foster Creek	70.7
Minn-UM-MINN-8e-13	East Fork Blue Earth River	182.7
Minn-UM-MINN-8e-14	South Creek	114.4
Minn-UM-MINN-8e-15	Center Creek	139.7
Minn-UM-MINN-8e-16	Cedar Lake	54.2
Minn-UM-MINN-8e-17	Elm Creek	218.6
Minn-UM-MINN-8e-18	Willow Creek	72.9
WATONWAN RIVER - 8e1		
Minn-UM-MINN-8e1-01	Upper Watonwan River	210.3
Minn-UM-MINN-8e1-02	Butterfield Creek	62.4
Minn-UM-MINN-8e1-03	St. James Creek	60.6
Minn-UM-MINN-8e1-04	Lake Hanska	55.1
Minn-UM-MINN-8e1-05	Linden School Lakes	30.2
Minn-UM-MINN-8e1-06	Bingham Lake	47.8
Minn-UM-MINN-8e1-07	Upper South Fork Watonwan River	69.5
Minn-UM-MINN-8e1-08	Willow Creek	32.2
Minn-UM-MINN-8e1-09	South Fork Watonwan River	68.7
Minn-UM-MINN-8e1-10	South Fork Spring Branch Crk.	11.1
Minn-UM-MINN-8e1-11	Spring Branch Creek	23.4
Minn-UM-MINN-8e1-12	Perch Creek	110.2
Minn-UM-MINN-8e1-13	Watonwan River	85.1
LESUEUR RIVER - 8e2		
Minn-UM-MINN-8e2-01	LeSueur River	287.1
Minn-UM-MINN-8e2-02	Boot Creek	40.0
Minn-UM-MINN-8e2-03	Little LeSueur River	21.9
Minn-UM-MINN-8e2-04	Janesville Village	85.0
Minn-UM-MINN-8e2-05	Madison Lake	16.4
Minn-UM-MINN-8e2-06	Little Cobb River	123.7
Minn-UM-MINN-8e2-07	Cobb River	165.0
Minn-UM-MINN-8e2-08	Easton	63.2
Minn-UM-MINN-8e2-09	Rice Creek	86.7
Minn-UM-MINN-8e2-10	Amboy	21.1
Minn-UM-MINN-8e2-11	Maple River	177.5

The maximum monthly average of 4.62 inches occurs in June and the minimum monthly average, 0.81 inch, falls in January. The average annual snowfall is about 40 inches or about 14 percent of the annual precipitation. The average basin total seasonal snowfall (November to April) for recent years, and the high total annual snowfall in the subbasin are as follows: 59 inches in 1969, 69 inches in 1965, and 76 inches in 1962. The greatest annual snowfalls for three stations in or near the subbasin with long records are: Fairmont, 92.6 inches in 1909; Albert Lea, 97.0 inches in 1909; and Waseca Experiment Station, 88.2 inches in 1951. Figure 3.3 shows the average monthly precipitation for the subbasin.

C. Evaporation

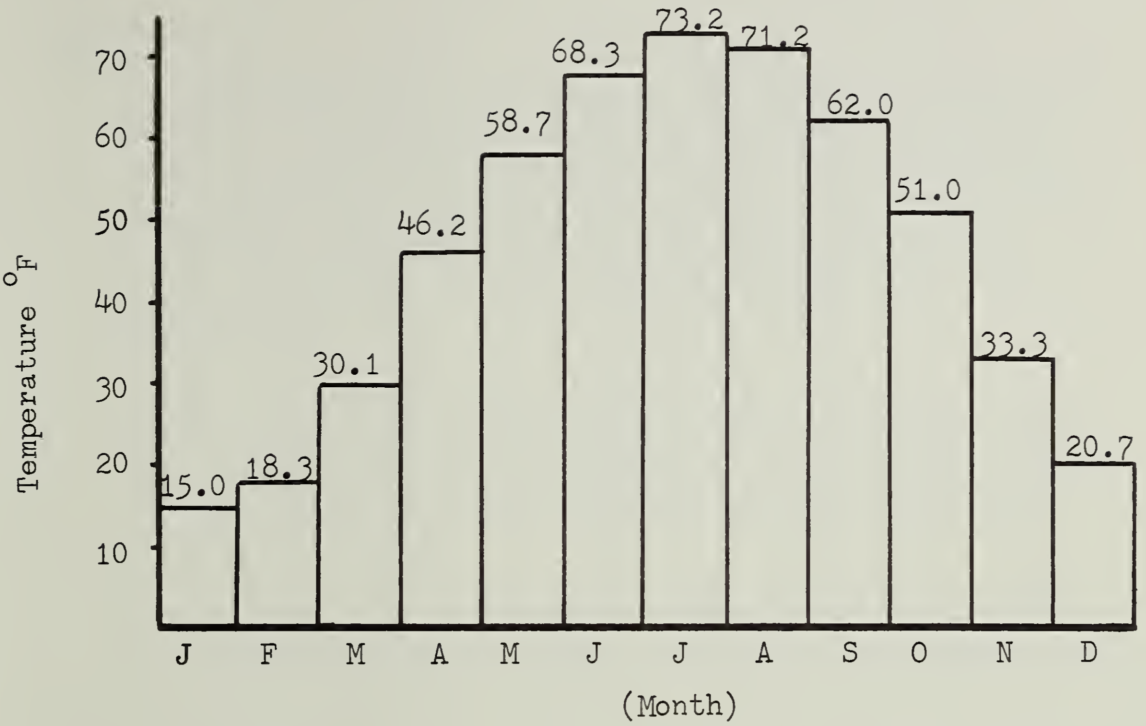
Evaporation records in the Blue Earth River Subbasin have been published for the Waseca Experiment Station for the summer months (April through September) since April 1964. The average annual lake evaporation for the subbasin is about 33 inches according to "Weather Bureau Technical Paper No. 37; Evaporation Maps for the United States." Net evaporation (mean annual evaporation less precipitation) averages about 5 inches a year.

D. Notable Storms

A major storm near the subbasin occurred on 16 and 17 June 1957 when excessive rains fell over southwestern Minnesota during which many stations established new record 24-hour totals. A few were Marshall, 8.07 inches; Minneota, 8.67 inches; Tyler, 8.57 inches; and Montevideo, 7.30 inches, all located approximately 55 miles northwest of the Blue Earth River Subbasin. The most recent storm occurred on 7 August 1968 near the northern edge of the basin with the greatest 1-day precipitation of 7.09 inches at North Mankato and 8.62 inches at St. Peter.

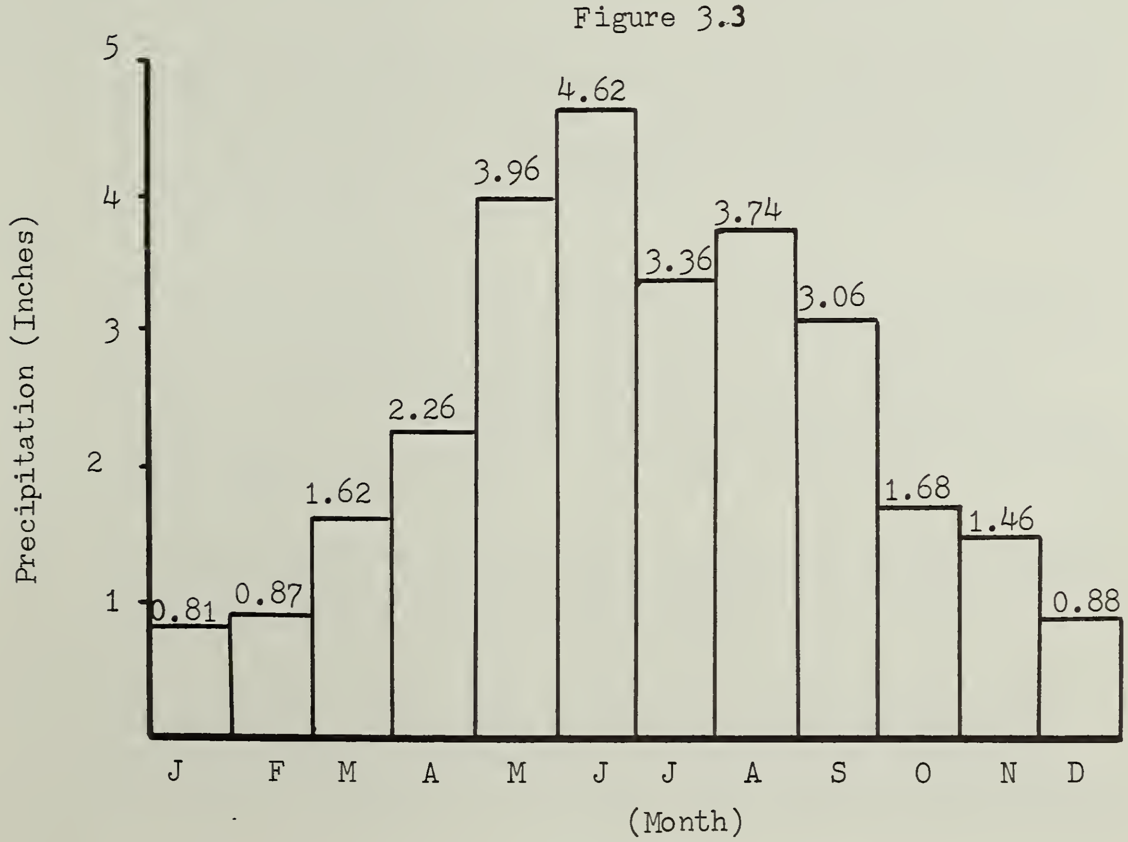
The greatest storms in the region include those of 17-18 September 1926 in which 24.0 inches fell within 24 hours at Boyden, Iowa, about 60 miles southwest of the edge of the Blue Earth River Subbasin; and 14-17 July 1900 during which 12.3 inches fell in 24 hours at Primghar, Iowa, about 60 miles southwest of the Blue Earth River Subbasin. The greatest 24 hour precipitation amount through 1950 for a station in the approximate center of the subbasin is 6.22 inches at Winnebago on 10 August 1948. An intense storm centered at Albert Lea, 10 miles east of the subbasin, on 4-5 July 1943, resulted in 8.25 inches in a 24 hour period and 6.25 inches in a 2 hour period.

Figure 3.2



Average Temperature, Blue Earth River Subbasin, 1931-1960

Figure 3.3



Average Precipitation - Blue Earth River Subbasin, 1931-1960

3. Physiography and Geology

A. Topography

The subbasin lies in the central lowlands physiographic province. The dominant topography consists of a nearly level to gently rolling glacial drift plain. Relief is comprised of 42 percent gently rolling, 4 percent rolling, 13 percent level topped hills with smooth side slopes, 37 percent gently undulating ground moraines and flat glacial lake features and 4 percent outwash valley trains and alluvium.

Relief differences are dominantly ten to twenty feet but range from five feet on the lake plains to several hundred feet along the stream entrenchments. Closed depressions and dead lakes are common features with few first and second order streams.

The elevation in the subbasin ranges from about 1500 feet in Cottonwood County to about 750 feet at the mouth of the Blue Earth River near Mankato.

B. Glacial Geology

The entire subbasin has been overrun several times by continental glaciers, however only the deposits from the latest ice stage are recognizable at the surface.

The last ice sheet advanced down the Red River Valley from Canada, thence down the Minnesota Valley penetrating to Des Moines before retreating. This last advance retreated about 10,000 years ago and geologists have appropriately named this river of ice the Mankato Glacial Lobe of the Wisconsin Glacial Stage.

The nutrient rich, highly productive soils in the subbasin owe their existence to the glaciers. The creeping river of ice, like a giant bulldozer, ripped and tore the ledges of rock it traversed, mixing, grinding, and spreading the materials over the existing uneven landscape leaving behind a flat to gently undulating surface idealy suited for modern large scale agriculture.

The composition of the glacial materials is fairly uniform over the subbasin except for the southwestern portion where the glacial till is more clayey.

The erratic melting rate of the ice front as it retreated northward left low, broad mounds and ridges of material. One of these low broad moraines occupies eastern Waseca and Steele Counties and separates the LeSueur River drainage

from the Straight River. A belt of high moraines form the western watershed divide between the Des Moines River and the Blue Earth River Subbasin and in Cottonwood and Jackson Counties forms the highest elevation in the watershed.

The melting glacial ice released great volumes of water which flowed around the edges of the ice scouring valleys in the glacial till and depositing extensive layers of sand and gravel. The ice blocked natural drainages and ponded water against the ice dams forming temporary lakes and caused waters to flow over into the Des Moines River system. The affects of the melt water rivers are prominent in northern Watonwan and Brown Counties as evidenced by Hanska and Wood Lakes and the gravel deposits in that area. The three chains of lakes in Martin County occupy melt water channels that drained towards the south. In the later stages of melting, the Blue Earth and LeSueur Rivers were established with their associated outwash terrace gravels and alluvium.

Temporary glacial lakes deposited silt layers over the glacial till. One of these lakes, Lake Minnesota, occupied much of the central portion of the subbasin.

C. Bedrock Geology

The bedrock is covered by glacial deposits over the entire subbasin except for small exposures of Sioux Quartzite along the North Branch of the Watonwan River and exposures of limestone, sandstone and shale along the entrenched section of the Blue Earth and LeSueur Rivers in the vicinity of Mankato.

The mantle of glacial deposits are generally over one hundred feet thick but are thinnest in the northwestern side of the watershed.

Cretaceous shale underlies Blue Earth, Watonwan, Martin, Jackson and northwest corner of Faribault Counties.

Paleozoic limestone, sandstone and shale underly Waseca, Steele and Freeborn Counties. The beds dip gently to the southeast. The sandstone layers are excellent aquifers and provide an abundant quantity and good quality water to drilled wells.

Pre-cambrian Sioux Quartzite underlies Cottonwood, Brown and the western tier of townships in Watonwan County. The quartzite is a poor aquifer.

D. Soils

The soils in the subbasin are predominantly medium to fine textured prairie soils of the Clarion-Nicollet-Webster soil association. They are dark colored soils formed from calcareous loam till of Wisconsin age. Clarion loam is well drained, slightly acid and occurs on slopes. Nicollet loam is moderately well drained and occupies nearly level areas. Webster clay loam is poorly drained and occurs in level areas. Soils formed from glacial outwash (Wadena, Hubbard) are common along streams.

For a complete description of the soils in the subbasin see Appendix 2.

E. Mineral Resources

The mineral resources of the Blue Earth Subbasin consist of sand and gravel deposits which are used primarily for road surfacing either in the natural state or as concrete and bituminous aggregates. They are also used for concrete aggregate for building construction and the manufacture of concrete block and concrete pipe. Sioux quartzite is suitable for the above purpose and in addition may be used for building stone, landscaping stone and riprap.

The paleozoic limestone may be used for agriculture lime and road surfacing materials.

F. Natural Features

The stream drainage patterns, sediment yield and runoff characteristics of this subbasin were determined by the topography and materials left by the latest glaciation. The streams have merely occupied the low points and glacial meltwater channels left by the retreating ice sheets.

In most unglaciated areas the stream systems have carved their own characteristic valleys out of the landscape and have established well defined watershed divides, thick deposits of valley alluvium and well developed floodplains. Stream gradients and valley widths become flatter and wider respectively as the outlet is approached.

In contrast, the Blue Earth Subbasin stream systems occupy recently glaciated topography which is characterized by extreme irregularity in floodplain widths, poorly defined watershed divides and irregular, non-uniform stream gradients.

The uplands are characterized by low gradient, unicised,

low density natural drainage networks. As the valleys extend downstream they become more deeply entrenched and the streams have steeper gradients. Approximately ten miles from the mouth, the Blue Earth River is bordered by steep valley walls that rise 200 feet to the regional plain.

4. Land Resources

A. Land Resource Areas and Soil Suitability

The Blue Earth River Subbasin lies entirely in Land Resource Area 103, Central Iowa and Minnesota Till Prairies, which is included in the Central Feed Grains and Livestock Land Resource Region. Fertile soils and favorable climate make this one of the outstanding grain producing regions of the world. Many of the counties in the Minnesota portion of the subbasin are among the highest in crop yields in the state.

B. Supply and Geographic Distribution

Nowhere in the area of northeastern North America that was glaciated is there a more typical example of ground moraine left in the wake of a continental ice sheet than is exhibited by the extensive, slightly undulating, monotonous expanses of southcentral Minnesota.[1/]

This statement best describes the supply and general distribution of the land resource in the subbasin. In a broad sense the land may be thought of as homogeneous in that there is no large area of land that significantly differentiates itself from another from the resource standpoint.

Nearly all of the area is in farms and about 90 percent is cropland. Wooded areas are mainly narrow bands along streams and surrounding lakes and marshes except for shelterbelts around farmsteads. Pasture land is found along streams and in small areas near farmsteads.

C. Vegetation

At one time tall prairie grasses such as bluestem were dominant in the plant community and covered nearly all of the land in the subbasin. Now most of the land is covered with a grass and legume rotation of corn and soybeans. Bluegrass is found along the streams, in small pastures near farmsteads and in farmyards.

1/The Geology and Underground Waters of Minnesota, George A. Thiel, University of Minnesota Press, 1944.

The major variety of trees found along the streams and lakes are oak, elm, basswood, ash, maple and the poplar species. Spruce, green ash, poplar and honeysuckle are found in shelterbelts around farmsteads.

Carex sedges, and water tolerant grasses such as rice cut grass, manna grass and prairie cord grass are found adjacent to shallow lakes and in marshes and swamps.

D. Use and Management

89.5 percent of the land is in cropland, 3.2 percent in pasture, and 2.6 percent in forest. The remaining 4.7 percent is divided between other agricultural uses, urban use, water areas, roads, parks, etc.

The major crops are corn and soybeans with secondary crop production of small grain and hay. Some specialty crops such as sweet corn and peas are also grown. Because of the predominant agricultural nature of the subbasin, land management involves, to a great extent, that which applies to agriculture. Water management as an element of land management has led to extensive drainage of lands to increase crop production. Technological revolution in farming has led to continuous row cropping systems rather than traditional crop rotations. Pasture and woodland is managed in large part by nature with the exception of some improved pasture land and some woodland areas managed for recreation and shelterbelts. Programs are in effect to manage existing wildlife areas for that purpose and to promote increased fish and wildlife development. Zoning as a political land management tool is a relatively young concept in the subbasin, but is becoming important as counties develop regulations of this kind.

5. Water Resources[1/]

A. Surface Water

(1) Water Yield

The average annual runoff from the subbasin is about 4.8 inches, based on streamflow data for the period 1940-69. Runoff ranges from less than 4 inches at the western border to about 5.5 inches in the eastern part of the subbasin.

1/Portions taken from 1971 open file report, Water Resources of the Blue Earth River Watershed, South Central Minnesota, H. W. Anderson, Jr., D. F. Farrell, and W. L. Broussard, U. S. Geological Survey.

(2) Geographic and Seasonal Distribution

Runoff is greatest during the spring and early summer when snowmelt occurs and the soils are generally saturated. High runoff may occur during the summer following thunderstorms although this generally occurs on small areas. Runoff recedes during late summer and fall to the lowest values during late winter. Generally the most uniform daily discharge occurs just prior to spring breakup and, in contrast, the least uniform occurs in the summer.

The small tributary streams are dry during the fall and winter in many years because they have little natural storage and little ground water contribution. The main streams of the Blue Earth, LeSueur, and Watonwan Rivers have very little or no flow during prolonged periods of low precipitation.

The frequency of recurrence of the long periods of low flow during the drought of the 1930's cannot be adequately defined by the short length of streamflow records in the subbasin.

(3) Lakes*1/

There are 468 lakes in the Minnesota portion of the subbasin which have an area of 10 acres or more. See Table 3.3. Three hundred of these 468 lakes have been drained or partly drained by tile, artificial ditches or deepening of natural channels. The subbasin undoubtedly contained many more shallow lakes but all traces of them have disappeared, through drainage and sedimentation.

The majority of the lakes were formed by irregular deposition of glacial till or by stagnant ice blocks deposited in glacial till. Since the lakes were formed in this manner most of them are shallow and are distributed in a random fashion throughout the subbasin. Most of the lakes have a small ratio of surface drainage area to lake area and depend on ground water to maintain the lake level. Only a few of the lakes are located directly on the downstream portion of the major drainageways.

*For the purpose of this report a lake is defined as a natural enclosed depression, 10 acres or more in area which has substantial banks capable of containing water and which are discernible on aerial photographs.

1/Bulletin 25, An Inventory of Minnesota Lakes, Minnesota Department of Conservation, Division of Waters, Soils and Minerals, St. Paul, Minn. 1968.

Table 3.3

Lakes Classified by Area (Minnesota Portion of Basin Only)
Blue Earth River Subbasin

COUNTY		Area in Acres							Total Number (No.)	Total Area (Acres)
		10-50	50-100	100-150	150-200	200-500	500-1000	1000 or Larger		
Blue Earth	Total Number	35	26	16	3	11	1	4	96	13,698
	No. Affected by Drainage or Dry	30	25	13	2	9	0	3	82	10,460
Brown	Total Number					1		2	3	3,422
	No. Affected by Drainage or Dry					1		1	2	1,578
Cottonwood	Total Number	5	7	1	1	3		1	18	2,705
	No. Affected by Drainage or Dry	3	1	0	0	1		1	6	1,353
Faribault	Total Number	41	27	7	4	8	1	3	91	12,240
	No. Affected by Drainage or Dry	36	25	7	3	6	0	1	78	7,570
Freeborn	Total Number	4	1	1	1	2		1	10	3,426
	No. Affected by Drainage or Dry	2	0	1	0	2		0	5	888
Jackson	Total Number	4	3	1	1	1			10	1,127
	No. Affected by Drainage or Dry	4	2	1	1	0			8	681
Le Sueur	Total Number	1	1						2	87
	No. Affected by Drainage or Dry		1						1	68
Martin	Total Number	41	22	12	6	12	4		97	11,939
	No. Affected by Drainage or Dry	16	7	5	0	1	0		29	1,966
Steele	Total Number	3	2	1	2				8	667
	No. Affected by Drainage or Dry	3	1	1	2				7	608
Waseca	Total Number	27	30	9	1	3	1	1	72	8,557
	No. Affected by Drainage or Dry	23	28	7	1	0	0	0	59	3,772
Watonwan	Total Number	35	10	5	6	4	1		61	5,166
	No. Affected by Drainage or Dry	13	6		4	0	0		23	1,892
Totals	Total Number	196	129	53	25	45	8	12	468	63,034
	No. Affected by Drainage or Dry	130	96	35	13	20	0	6	300	30,836

The total area of the 468 lake basins as defined in this report is 63,034 acres. The total area of the 168 lake basins which are not affected by drainage is 32,198 acres.

(4) Water Quality

The concentrations of calcium and magnesium are high for most streams in the subbasin so consequently the water is very hard. Nutrients (nitrogen and phosphrous compounds) are high in most of the streams as evidenced by the algae bloom in many of the lakes.

(5) Water Use and Management

Fairmont is the only community in the subbasin that uses surface water for municipal supply. The city uses the waters of Budd Lake in addition to wells.

Water for irrigation is obtained from the Watonwan River in the northeast part of Watonwan County. About 800 acres of corn and soybeans are presently being irrigated on six farms.

Recreation, fish and wildlife, and the aesthetic value of looking at water are other major uses of the surface water.

Surface water in streams is also used to dilute sewage treatment plant effluents.

The primary water management aspect in the subbasin is the drainage of excess water from cropland. There are tens of thousands of miles of drain tile in the subbasin. Other management of surface water includes management for flood control, fish and wildlife development, lake level control for recreation, and pollution control.

B. Ground Water

Aquifers throughout the subbasin serve two major functions in the hydraulic system; they are sources of water supplies, and they furnish a perennial base of stream flow by ground-water discharge.

(1) Water Yield

At present (1971), no areas of significant ground water decline are known, indicating that only part of the available ground water has been developed. However,

because ground water availability varies locally, detailed studies are necessary to guide resource development, especially where large ground water supplies are needed.

(2) Geographic Distribution

Water supplies are obtained from wells tapping Pleistocene glacial deposits, Ordovician and Cambrian sedimentary rocks, and Precambrian crystalline rocks. In the western part of the subbasin, glacial sand and gravel (generally buried) form the most accessible and widely used aquifers. Toward the east, increasing numbers of wells obtain water from Ordovician and Cambrian rocks. The Jordan Sandstone, St. Peter Sandstone, and Galena Formation are the most reliable and widely used aquifers in the central and eastern part of the subbasin.

Most of the Blue Earth River Subbasin is an area of ground-water recharge, indicated by a decrease in hydraulic potential as depth below land surface increases. Ground-water discharge to surface runoff and to evapotranspiration is generally localized near streams, and increases toward Mankato at the north central edge of the watershed.

Dominant regional ground-water flow converges on Mankato where the surface flow also discharges from the Blue Earth River into the Minnesota River. In the higher areas along the edge of the basin there is also significant downward flow. Some of this downward flow on the east and southeast is diverted out of the watershed.

(3) Water Quality

The chemical quality of ground water from the aquifers is generally good although in some areas hardness is moderate to extreme with excessive amounts of iron and manganese present. There is a marked decrease in mineralization between the western parts of the subbasin and the eastern part. The cause is found in the composition of the glacial deposits. Glacial deposits in the western part of the subbasin are derived from cretaceous sediments which produce highly mineralized water.

(4) Water Use and Management

All communities with the exception of Fairmont use ground water for their only source of supply. Practically all water for industrial and rural domestic

use also comes from ground water. The use of ground water in the subbasin is estimated at 6,428 million gallons a year.

Table 3.4 lists the communities in the subbasin (or very near the subbasin) with central water supplies, their related plant capacity and average daily use.

Table 3.4

Municipal Water Supplies[1/]
Blue Earth River Subbasin

State	County	Community	1960 Population Served	Rated Plant Capacity (MGD)	Average Plant Output (MGD)
Minnesota	Blue Earth	Amboy	630	1.20	0.022
		Eagle Lake	505	0.50	0.045
		Good Thunder	470	0.36	0.004
		Madison Lake	475	0.40	0.043
		Mankato	23,800	10.00	3.500
		Mapleton	1,085	0.87	0.098
		Pemberton	175	0.20	0.016
		Rapidan	150	0.20	0.014
		Saint Clair	375	0.18	0.030
		Skyline	355	0.20	0.032
		South View Hts.	250	0.20	0.022
		Vernon Center	335	0.14	0.014
	Cottonwood	Mountain Lake	1,950	0.57	0.175
	Faribault	Blue Earth	4,200	2.10	0.200
		Bricelyn	540	0.80	0.048
		Delavan	320	0.11	0.012
		Easton	410	0.80	0.006
		Elmore	1,100	0.33	0.050
		Frost	380	0.20	0.024
		Kiester	740	0.30	0.060
		Minnesota Lake	700	0.82	0.063
		Walters	140	0.20	0.009
		Wells	2,900	0.86	0.260
		Winnebago	2,100	1.05	0.190
	Freeborn	Alden	700	0.58	0.060
		Freeborn	320	0.29	0.030
		Hartland	330	N. A.	0.030
	LeSueur	Elysian	380	0.20	0.035

1/Appendix F, Interim Survey Report on the Blue Earth River, Minnesota, St. Paul District, Corps of Engineers
N. A. - Information not available

Table 3.4 (Cont.)

Municipal Water Supplies
Blue Earth River Subbasin

State	County	Community	1960 Population Served	Rated Plant Capacity (MGD)	Average Plant Output (MGD)
Minnesota	Martin	Fairmont*	9,745	4.50	0.450
		Granada	420	0.20	0.040
		Northrop	190	0.10	0.030
		Sherburn	1,230	0.46	0.110
		Trimont	940	0.20	0.080
		Truman	1,260	0.20	0.110
		Welcome	735	0.23	0.070
	Waseca	Janesville	1,425	0.36	0.075
		New Richland	1,045	2.60	0.090
		Waldorf	270	0.44	0.020
		Waseca	5,900	5.20	0.350
	Watonwan	Butterfield	600	0.50	0.050
		Darfur	190	N. A.	0.014
		Lewisville	375	0.14	0.030
		Madelia	2,190	0.72	0.200
		Ormsby	220	N. A.	0.020
		St. James	4,175	1.20	0.280
Iowa	Kossuth	Lakota	460	0.14	0.040
		Ledyard	290	N. A.	0.022
	Winnebago	Buffalo Center	1,140	N. A.	0.100
		Rake	330	N. A.	0.025

N. A. - Information not available
* Supplied from Budd Lake and wells

Ground water management is centered around control of wastes so as not to pollute the ground waters and the state law which requires a permit for the appropriation of ground water.

6. Fish and Wildlife Resources*

   A. Game and Commercial species

      (1) Habitat availability
      (2) Habitat condition
      (3) Other factors

7. Quality of the Natural Environment*

   A. Scenic Beauty

   B. Destructive Factors

*Investigations are being made by the Soil Conservation Service. Studies need to be coordinated with state and federal agencies.

IV. ECONOMIC DEVELOPMENT

The present and future economy of the Blue Earth River Subbasin is dependent on the quantity and quality of natural resources and the people in the subbasin. Historical development, social structures, and institutions have determined the present economy, but they will have less influence on the future economy as influences outside the basin and the values and goals of the people change. Current ēconomic activities and trends that may affect future water and land resources of the subbasin are presented to indicate the economic development of the area.

1. Historical Development

With the Louisana Purchase in 1803, the land which is now Minnesota became a part of the United State's public domain. Prior to this time, the south central area of Minnesota was a wilderness of prairie grass with some hardwood forest inhabited by wild game, a few roving Indians and French fur traders. The Sioux Indians controlled most of the area until their surrender in 1851, waging numerous wars with other tribes and white men encroaching on the area. Settlement rapidly followed this land acquisition from the Sioux Indians and communities and counties were established thereafter. Most of the counties included in the Blue Earth River Subbasin were established and named prior to 1860. Minnesota was granted statehood in 1858.

A number of the early settlers that came to Minnesota were descendents of New England Colonists. Later in the century, immigrants from northern Europe, especially Germany and Sweden, settled in the area, carved farms from the wilderness and established their communities. For a transportation outlet, most of the communities developed near one of the rivers. Land grants to enhance development were later made to companies to build railroads in the area. By 1870, over 2,000 miles of railroad had been built in Minnesota connecting the area to Chicago and the Great Lakes. The establishment of the railroads provided farmers access to a market for their products which made rapid agricultural development possible. Population in the subbasin increased to nearly 100,000 by the turn of the century.

The Blue Earth River Subbasin includes the drainage area of the LeSueur, Watonwan, and Blue Earth Rivers. This area occupies parts of ten counties in Minnesota and three counties in Iowa. The five counties of Blue Earth, Faribault, Martin, Waseca, and Watonwan closely approximate this drainage area

Rural population for the Blue Earth River Subbasin was estimated from Census of Population data by expanding the rural population density of Blue Earth, Faribault, Martin, Waseca, and Watonwan counties to the subbasin area. Urban population for the subbasin include all cities within the drainage area boundary with a

population of 2,500 or more persons. Business activities and nonagricultural employment were estimated from Census of Business data by applying the ratio of urban population of the five county area to urban population of the subbasin.

2. General Characteristics

A. Population and Population Characteristics

Population trends and characteristics of the Blue Earth River Subbasin are similar to most other mid-western agricultural areas. Total population has remained nearly stable while urban population has increased and rural population has decreased for the last several decades. Total 1970 subbasin population equaled 105,842, a decrease of 6,114 from the 1960 population (Table 4.1). Urban population increased 54 percent and rural population decreased 14 percent between 1940 and 1970. Population density of the Blue Earth River Subbasin in 1970 was 30 persons per square mile.

Increased farm mechanization and off-farm employment opportunities have resulted in a large migration from rural to urban areas. The change in the proportion of population living in urban areas from 1940 to 1970 is evidence of this trend (Table 4.2). Over 83 percent of the total population lived in rural areas in 1940 compared to 73 percent in 1970. Approximately 6 percent of the population lived in towns over 5,000 in 1940 compared to 16 percent in 1970.

Twelve cities or villages in the Blue Earth River Subbasin had populations of over 1,000 persons in 1970 (Table 4.3). The greatest concentration of population occurs in the City of Fairmont with a 1970 population of 10,751 persons. The City of Mankato is not included as a part of the Blue Earth River Subbasin since only a small segment of the city is located within the drainage area. Changes in population in an area results from the difference in number of births and deaths and net migration in or out of an area. Net migration is an important indicator of employment and economic activity in an area. Five of the thirteen counties in the Blue Earth River Subbasin had an increase in population during the 1960's, but only one had a net in migration (Table 4.4). Because of the growth of Mankato, Blue Earth County had a population increase of 7,937 persons in the 1960's and one-third of that increase was from migration into the County. All counties in the subbasin reported a natural increase in population during the 1960's, but migration was an important influence on the total change in population.

Table 4.1

Population and Percentage Population by Place of Residence, Blue Earth River Subbasin, 1940-1970.1/

	1940	1950	1960	1970
Total population	109,125	108,399	111,956	105,842
Urban population	18,360	20,824	26,914	28,323
Places 5000 and over	6,988	8,193	15,643	17,540
Places of 2500 - 4999	11,372	12,631	11,271	10,783
Rural population*	90,765	87,575	85,042	77,519
Rural non-farm	29,295	34,747	40,495	**
Rural farm	61,470	52,828	44,547	**
Total population	100.0%	100.0%	100.0%	100.0%
Urban population	16.8	19.2	24.0	26.8
Places 5000 and over	6.4	7.6	14.0	16.6
Places 2500 - 4999	10.4	11.7	10.0	10.2
Rural population*	83.2	80.8	76.0	73.2
Rural non-farm	26.8	32.0	36.0	**
Rural farm	56.3	48.7	40.0	**

1/U. S. Department of Commerce, Bureau of Census, U. S. Census of Populations, 1940, 1950, 1960, and 1970.

* Rural population for the subbasin was estimated from rural population density in the area.

** Rural farm and rural non-farm population are not available at time of writing.

Table 4.2

Index of Changes in Population by Place of Residence, 1940 = 100 1/
Blue Earth River Subbasin

	1950	1960	1970
Total population	99.3	102.6	97.0
Urban population	113.4	146.6	154.3
Places 5000 and over	117.2	223.8	251.0
Places 2500 - 4999	111.0	99.1	94.8
Rural population	96.5	93.7	85.4
Rural non-farm	118.6	138.2	*
Rural farm	85.9	72.4	*

1/ U. S. Department of Commerce, Bureau of Census, U. S. Census of Populations, 1940, 1950, 1960, and 1970.

* Rural farm and rural non-farm populations are not available.

Table 4.3

Population of Places over 1,000, 1940 - 1970 1/
Blue Earth River Subbasin

	1940	1950	1960	1970
Fairmont	6,988	8,193	9,745	10,751
Waseca	4,270	4,927	5,898	6,789
St. James	3,400	3,861	4,174	4,027
Blue Earth	3,702	3,843	4,200	3,965
Wells	2,217	2,475	2,897	2,791
Madelia	1,652	1,790	2,190	2,316
Mountain Lake	1,745	1,733	1,943	1,986
Winnebago	1,992	2,127	2,088	1,791
Janesville	1,296	1,287	1,557	1,426
Mapleton	1,070	1,083	1,107	1,307
Buffalo Center, Ia.	911	1,087	1,118	1,140
New Richland	863	908	1,046	1,113

1/ U. S. Department of Commerce, Bureau of Census, U. S. Census of Populations, 1940, 1950, 1960, 1970.

Table 4.4

Natural Increase, Net Migration, and
Total Change in Population 1960 - 1970[1/]
Blue Earth River Subbasin

County	Births	Deaths	Natural Increase	Net Migration	Total Change
Blue Earth	9369	4286	5083	2854	7937
Brown	5758	2937	2821	-1610	1211
Cottonwood	2751	1619	1132	-2411	-1279
Faribault	3963	2443	1520	-4309	-2789
Freeborn	7241	3471	3770	-3579	173
Jackson	2511	1409	1102	-2251	-1149
Martin	4478	2478	2000	-4670	-2679
Steele	5368	2301	3067	-1165	1902
Waseca	3101	1627	1474	- 852	622
Watonwan	2458	1469	989	-2151	-1162
Emmet	2654	1534	1120	-1982	- 862
Kossuth	4813	2294	2519	-4896	-2377
Winnebago	2103	1449	654	- 763	- 109

1/ U. S. Department of Commerce, Bureau of Census, U. S. Census of Population, 1970.

The estimated population for the Blue Earth subbasin shows very little change over the last twenty years. This is in contrast to a 1.1 percent increase per year in population for the State of Minnesota and a 1.3 percent increase per year for the United States.

B. Social Structure and Institutional Arrangement

Social and institutional arrangements of the area reflect the culture of the founding forefathers. Social activities center around the church and schools which have had strong support among the small agricultural communities. Colleges in the area include Mankato State Teachers College and Bethany Lutheran College in Mankato.

Most small towns in the area are characterized by tall grain storage elevators and farm supply businesses. County seat towns are usually the major trade centers for the area as well as the center of government activities. Many communities are faced with problems of decreasing population and the loss of economic activity with the rural to urban migration.

C. Major Types of Economic Activities

Basic activities in the subbasin include agriculture and manufacturing with lumbering and mining activities having only a minor influence on total economic activity. Agricultural employment in 1960 was reported as 13,775 persons or 48 percent of total employment (Table 4.5). Employment in manufacturing was 12 percent of total employment. Agricultural employment decreased nearly 29 percent from 1950 to 1960 while manufacturing employment increased 75 percent. The City of Mankato on the subbasin boundary with a population of over 30,000 depends on the subbasin population for part of its labor force. Similarly, the City of Albert Lea with a population of nearly 20,000 located a few miles east of the subbasin draws on the area for part of its labor force.

Using the 1960 Census of Population, agricultural employment was estimated to be nearly 50 percent of total employment in the Blue Earth River Subbasin. Family and operator labor on farms is the major component of agricultural labor with hired labor consisting of less than 10 percent of the farm labor force. Using the 1969 Census of Agriculture, hired labor for the Blue Earth River Subbasin was estimated to be slightly over 1,200 persons.

Included in the farm labor force are farm operators who work part-time off the farm. Over 3,000 farm operators in the Blue Earth River Subbasin worked off the farm in 1969 and more than one-third worked more than 100 days off the farm.

Table 4.5

Employment in Blue Earth River Subbasin
1950, 1960, 1970 1/

Type of Employment	1950	1960	1970*
Agriculture	19,515	13,775	
Contract construction	1,613	1,349	
Manufacture of durable goods	2,043	3,583	
Communications or public utilities	1,213	1,265	
Wholesale and retail trade establishments	4,754	5,244	
Finance, insurance, and real estate	482	687	
Educational services	**	1,677	
Public administration	**	649	
Other employment	4,486	365	
Total employment	34,106	28,594	

1/ U. S. Department of Commerce, Bureau of Census, County and City Data Book, 1952, 1967.

* 1970 data not available at time of writing.

** Included in other employment.

Manufacturing in the Blue Earth River Subbasin complements the agricultural production in the area by processing farm produce and providing inputs for agricultural production. Industries closely related to agriculture in the area include the vegetable processing industry, meat packing industry, milk processing industry, feed mills and fertilizer blending plants. Vegetable processing plants are located in Fairmont, Blue Earth, Winnebago, Waseca, Bricelyn and Wells. The largest of these as reported by the Minnesota Directory of Manufacturers 1967-1968 had sales exceeding $10,000,000. A number of meat processing plants are located in the subbasin. Among the largest is a poultry processing company in St. James and Madelia with an employment of 500 persons and total sales exceeding $12,000,000. Many other establishments related closely to agricultural production include farm machinery dealers, fertilizer mixing plants, feed companies and other farm supply stores. Many of these are farm cooperatives, creameries and elevators established by farmers to obtain local markets for their products.

Other manufacturing includes metal and plastic containers, ready-mix concrete and concrete blocks, electrical equipment, precision measuring instruments, optical lenses, and mobile homes. A large number of printing and publishing firms are also located in the area.

Retail trade establishment activity can be an indication of total economic activity in the area. The number of retail trade establishments declined from 1954 to 1963 and increased from 1963 to 1967.1/ Most all types of retail businesses followed this pattern except building material, hardware, and farm equipment stores which show a continual decline. The depressed conditions of the nation during the late 1950's and early 1960's may explain the decline in the number of all retail trade establishments. The rural-urban migration as noted explains part of the decline in farm supply business.

A steady growth trend can be observed in all areas of economic activity in the subbasin (Table 4.6). Value added in manufacturing more than doubled between 1959 and 1967. The wholesale price index increased by only 21 percent during that time period. Increases in the value of sales of wholesale, retail, and selected service establishments are an indication of the economic growth which has taken place in the area. Value of total farm sales increased 62 percent between 1954 and 1969. The farm price index increased by only 3.7 percent during this time period.

1/Ibid

Table 4.6

Business Receipts 1954, 1958, 1963, 1967 1/
Blue Earth River Subbasin

	1954	1958	1963	1967
Value added in all manufacturing ($1,000)	24,693	30,903	41,226	70,300
Value of sales of retail establishments ($1,000)	88,758	93,477	98,319	122,980
Value of sales of wholesale establishments ($1,000)	69,247	94,583	99,288	119,592
Sales of selected service establishments ($1,000)	4,912	6,542	9,342	9,775
	1954	1959	1964	1969
Value of all farm products sold ($1,000)	113,956	135,505	162,254	184,594

1/ U. S. Department of Commerce, Bureau of Census, County and City Data Book, 1952 and 1957.

D. Incomes

In 1959, 29.7 percent of the families in the subbasin had incomes of less than $3,000.[1] Median family incomes for the subbasin ranged from $4,068 in Watonwan County to $4,887 in Blue Earth County. These incomes were significantly less than those of the state which had a medium income of $5,573. and the United States with a medium income of $5,660 in 1959. Eight percent of the families in the subbasin had incomes exceeding $10,000 in 1959. Comparatively, 13 percent of the families in Minnesota and 15 percent of the United States families had incomes exceeding $10,000.

E. Transportation

A railroad network of the Chicago-Northwestern and Chicago, Milwaukee, St. Paul and Pacific Railroads connect most all of the towns in the subbasin. Main roads in the subbasin include U. S. 169 and U. S. 16. Interstate 90 is proposed to extend across the southern part of the area and pass through Blue Earth and Fairmont. North Central Airlines provide service to the area from their terminals in Mankato and Fairmont.

F. Land Use

Total land area drained by the Blue Earth, LeSueur, and Watonwan Rivers is approximately 2.2 million acres. Large water areas including lakes greater than forty acres and rivers greater than one-eighth mile in width account for about 46,000 of these acres. Urban build-up and small water areas of two to forty acres total approximately 85,000 acres. Land available for agriculture and forestry drained by these rivers total to slightly over two million acres, as determined by the <u>1971 Conservation Needs Inventory</u> (Table 4.7). Of this two million acres, approximately 10 percent occurs in Emmet, Kossuth, and Winnebago Counties in Iowa.

Eighty-nine percent of the inventory acreage was reported to be used for cropland. The <u>Conservation Needs Inventory</u> shows that only 2 percent was defined as forest land and 3 percent as pasture and range land. The Minnesota portion of the Blue Earth River Subbasin represents 4 percent of the State's agricultural land, however it represents 7 percent of the State's cropland.

Land used for agriculture includes about 93.7 percent of the subbasin's total land area. Land used for urban build up

1/Source: U. S. Department of Commerce, Bureau of Census, County and City Data Book, 1967.

Table 4.7

Major Land Use 1/
Blue Earth River Subbasin

County	Cropland	Pasture	Forest	Other	Total
Blue Earth	301,873	9,367	23,579	15,659	350,478
Brown	26,542	686	190	2,514	29,932
Cottonwood	87,503	4,949		5,631	98,083
Faribault	410,350	500	12,000	15,450	438,300
Freeborn	65,117	4,591	835	8,140	78,683
Jackson	56,544	856	296	2,644	60,340
Martin	279,151	16,477	5,000	12,145	312,773
Steele	15,252	2,473	2,942	1,547	22,214
Waseca	176,280	11,612	5,506	10,349	203,747
Watonwan	244,324	6,954	4,300	13,645	269,223
Emmet	8,119				8,119
Kossuth	147,912	8,028		6,533	162,473
Winnebago	46,563	1,880	558	2,028	51,029
TOTAL	1,865,530	68,374	55,206	96,286	2,085,396

1/ Minnesota Conservation Needs Committee, Minnesota Soil and Water Conservation Needs Inventory, August, 1971.

accounts for less than 3.6 percent of the total area, and large water areas account for 2.1 percent of the total land area of the subbasin.

The agricultural land of Blue Earth, Faribault, Martin, Waseca, and Watonwan counties is approximately 88 percent of the agricultural land in the subbasin. Agricultural production of crops and livestock in the Blue Earth River Subbasin was estimated by expanding U. S. Census of Agriculture data on these five counties to the subbasin agricultural land area.

3. Agricultural Development

Over half of the farms in the Blue Earth River Subbasin are cash grain farms producing primarily corn for grain and soybeans (Table 4.8). Most of the other farms in the subbasin are livestock farms raising cattle and hogs. Less than 10 percent of the farms received their major source of income from dairy or poultry production.

Nearly all farms in the subbasin are commercial farms as defined by the Bureau of Census. Commercial farms include all farms with value of sales amounting to $2,500 or more, except institutional farms and Indian reservations. Farms with value of sales of $50 to $2,499 were included in commercial farms if the operator was under 65 years of age and did not work off the farm 100 or more days. Class I includes farms with value of sales of $40,000 or more; Class II with value of sales of $20,000 to $39,999; Class III with value of sales of $10,000 to $19,999; Class IV with value of sales of $5,000 to $9,999; Class V with value of sales of $2,500 to $4,999. Class VI includes all other commercial farms. As the number of total farms decrease and the production per farm increases, the proportion of farms in Class I has substantially increased. In 1954, about 4 percent of the commercial farms reported value of sales of $40,000 or more, while in 1969 nearly 12 percent of commercial farms reported value of sales of $40,000 or more.

The average value of farm products sold per farm in the Blue Earth River Subbasin in 1969 was $22,072 (Table 4.9). The value of field crops sold in 1969 totaled approximately 48 percent of all farm products sold. Livestock and livestock products contribute over 50 percent of all farm products sold, with most of the value of sales coming from hogs and beef cattle sold. Total land in farms as estimated from the U. S. Census of Agriculture increased between 1954 and 1964 and declined between 1964 and 1969. This decrease is accounted for by increases in urban and build-up areas and additional water areas.

Average farm size in the Blue Earth River Subbasin was 249 acres in 1969, an increase of 75 acres per farm from 1954. The average

Table 4.8

Number of Farms by Type, and Number of Farms by Economic Class, 1954, 1959, 1964 and 1969 1/
Blue Earth River Subbasin

	1954	1959	1964	1969
Total number of farms	12,230	11,033	9,795	8,363
Cash grain farms	5,005	4,335	4,941	*
Other field-crop farms	28	12	25	*
Vegetable farms	16	8	14	*
Fruit and nut farms	-	-	-	*
Poultry farms	477	165	114	*
Dairy farms	278	795	706	*
Livestock farms other than poultry or dairy farms	3,036	2,768	1,958	*
General farms	2,815	2,210	1,472	*
Misc. and unclassified farms	574	740	565	*
Commercial farms	11,691	10,317	9,285	7,880
Class I	484	378	524	923
Class II	3,878	1,075	1,936	2,237
Class III	4,721	3,529	3,628	2,431
Class IV	1,824	3,619	2,234	1,492
Class V	528	1,472	784	654
Class VI	256	244	179	143
Non-commercial farms	539	716	510	483

1/ IBID

* Unavailable at time of writing.

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Dairy farms	278	795	706	*
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General farms	2,815	2,210	1,472	*
Misc. and unclassified farms	574	740	565	*
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Class VI	256	244	179	143
Non-commercial farms	539	716	510	483

1/ IBID

* Unavailable at time of writing.

Table 4.9

Value of Farm Products Sold by Source, 1954, 1959, 1964, and 1969[1/]
Blue Earth River Subbasin, Minnesota

	1954	1959	1964	1969
All farm products sold ($1,000)	113,956	135,505	162,254	184,594
Average per farm	9,353	12,281	16,565	22,072
Field crops, other than vegetables and fruits and nuts sold ($1,000)	49,281	50,605	78,206	*
Vegetables sold ($1,000)	2,717	2,428	2,329	*
Fruits and nuts sold ($1,000)	12	22	18	*
Forest products and horticultural specialty products sold ($1,000)	479	577	557	*
Poultry and poultry products sold ($1,000)	9,144	8,718	7,912	*
Dairy products sold ($1,000)	8,294	10,646	12,888	*
Livestock and livestock products, other than poultry and dairy, sold ($1,000)	44,029	62,509	60,344	*

1/ IBID

* Unavailable at time of writing.

value of land and buildings in the subbasin is approximately $400 per acre. This represents an approximate investment of $100,000 in land and buildings by each farm operator in the subbasin (Table 4.10).

A. Major Crop Enterprises

Over half of the farms in the subbasin are cash grain farms producing primarily corn for grain and soybeans. Production of corn and soybeans has shown a steady increase while other crops grown in the area have shown a general decline. Nearly 55% of the land in farms was producing either corn or soybeans in 1969. During the 1960's the number of acres of soybeans has substantially increased while corn acreage has declined. Although corn acreage dropped between 1959 and 1969, total production increased (Table 4.11). Average yields for the subbasin from the U. S. Census of Agriculture data show a yield of 108 bu./acre in 1969 compared to 80 bu./acre in 1964 and 56 bu./acre in 1959. Yields for soybeans of the area increased to 30 bu./acre in 1969 from 24 bu./acre in 1959. About 4 percent of total corn acreage has been harvested as corn silage during the last fifteen years.

Although Minnesota ranks first in total oat production, the crop has a relatively small impact on total agricultural production in the area when compared to corn or soybeans. In 1969, 72,525 acres of oats were harvested in the subbasin. Oat production in 1969 was less than half of what it was ten years earlier because of decreased acreage. During this time oats yield increased about 18 bushels per acre. Wheat, barley, rye, and flax are also grown in the area but have only a small economic impact on the agricultural economy of the area.

Forage crops raised to support livestock farms are important to the agricultural economy. Along with the 4 percent of corn acreage cut for silage, 59,883 acres of alfalfa and alfalfa mixtures were cut for hay. Other hay crops include clover, timothy and mixtures of clover and other grasses, small grains, and wild hay. Total acreage of hay harvested has been decreasing.

Other crops of importance in the area include vegetable crops raised for canning or freezing. In 1969, 38,758 acres of vegetable crops were harvested in the subbasin with 28,162 acres of sweet corn and 9,930 acres of green peas harvested. Minnesota ranks first in production of sweet corn for processing and second in the production of green peas for processing. The Blue Earth River Subbasin acreage of sweet corn is approximately 25 percent of the State acreage, and green pea acreage is approximately 20 percent of the State acreage.

Table 4.10

Land in Farms and Value of Land and Buildings, 1954, 1959, 1964, and 1969[1/]
Blue Earth River Subbasin, Minnesota

	1954	1959	1964	1969
Total number of farms	12,183	11,033	9,795	8,363
Total land in farms (1,000 acres)	2,126	2,139	2,144	2,084
Average size of farm	174	194	219	249
Average value of land and buildings per farm	$36,622	$57,137	$62,922	$98,856
Average value of land and buildings per acre	$ 204	$ 295	$ 287	$ 397

1/ U. S. Department of Commerce, Bureau of Census, U. S. Census of Agriculture, 1954, 1959, 1964, 1969.

Table 4.11

Acreage and Production of Crops Harvested, 1954, 1959, 1964, and 1969 1/ Blue Earth River Subbasin, Minnesota

	1954	1959	1964	1969
Corn for all purpose (acres)	684,619	946,723	746,428	614,289
Corn for grain (acres)	650,956	902,782	712,759	587,670
Corn for silage (acres)	27,594	39,642	31,841	28,817
Soybeans for all purposes (acres)	371,745	356,208	494,698	*
Soybeans for beans (acres)	371,249	355,501	494,531	530,902
All wheat (acres)	3,858	60,075	32,202	17,610
Spring wheat (acres)	2,845	56,543	29,602	*
Oats (acres)	365,498	198,288	111,780	72,525
Barley (acres)	2,665	2,487	398	291
Rye (acres)	850	1,447	1,377	206
Flax (acres)	14,874	3,966	1,085	*
Corn for grain (1,000 bu.)	40,129	50,521	57,029	63,430
Corn for silage (1,000 tons)	315	406	441	375
Soybeans for beans (1,000 bu.)	9,795	8,435	13,131	16,164
All wheat (1,000 bu.)	74	1,767	781	519
Spring wheat (1,000 bu.)	59	1,680	774	*
Oats (1,000 bu.)	14,537	9,800	6,650	4,874
Barley (1,000 bu.)	93	97	18	12
Rye (1,000 bu.)	18	41	44	6
Flax (1,000 bu.)	65	155	17	*
Alfalfa & alfalfa mixtures cut for hay (acres)	96,876	105,575	100,180	59,883
Clover, timothy and mixtures of clover and grasses cut for hay (acres)	13,992	7,391	5,079	3,142
Oats, wheat, barley, rye, or other small grains, cut for hay (acres)	894	1,532	1,079	798
Wild hay cut (acres)	23,862	10,826	7,195	**
Other hay cut (acres)	4,135	2,717	1,526	4,787
Alfalfa & alfalfa mixtures cut for hay (1,000 tons)	273	312	327	214
Clover, timothy, & mixtures of clover and grasses cut for hay (1,000 tons)	31	9	10	8

* Unavailable at time of writing.

** Included in other hay.

Table 4.11 (cont.)

	1954	1959	1964	1969
Oats, wheat, barley, rye, or other small grains cut for hay (tons)	1	3	2	2
Wild hay cut (tons)	34	15	**	**
Other hay cut (tons)	7	5	3	8
Red clover seed (acres)	1,704	527	318	45
Timothy seed (acres)	6	3	98	*
Irish potatoes for home use or sale (acres)	546	656	321	241
Vegetables harvested for sale (acres)	51,738	49,912	40,907	38,758
Sweet corn harvested for sale (acres)	26,247	29,473	25,427	28,162
Green peas harvested for sale (acres)	14,082	16,098	13,325	9,930
Sugar beets (acres)		3,106	8,889	
Tree fruits, nuts, groves and vineyards (acres)	389	255	155	*
Red clover seed (1,000 lbs.)	137	22	25	2
Timothy seed (1,000 lbs.)	1	1	20	*
Irish potatoes for home use or sale (cwt.)	65,521	110,118	96,229	*
Sugar beets (1,000 tons)		37,292	110,803	*

1/ U. S. Department of Commerce, Bureau of Census, Census of Agriculture, 1954, 1959, 1964 and 1969.

* Unavailable at time of writing.

** Included in other hay.

B. Livestock Enterprises

Livestock enterprises in the subbasin are typical of the Corn Belt Region consisting of hog farrowing and feeding operations, cattle feeding and beef cow herds, and a significant number of dairy farms. Sheep and lambs and poultry are grown in the subbasin, but are of less importance (Table 4.12). A great amount of fluctuation has taken place during the last fifteen years in livestock production of the area as is shown by the Census data. Because of the cyclic production patterns associated with livestock, it is not possible to determine any definite trends in production, however it appears that the number of cattle on farms and cattle sold may have reached a long term peak in 1964 and a general decline is now taking place.

In 1969, 180,686 cattle and calves were reported sold which represent a decrease of nearly 15,000 head from five years earlier. The 742,525 head of hogs raised in the Blue Earth River Subbasin represents over one-fifth of the 1969 total hog production in the State of Minnesota. The number of milk cows in the Blue Earth River Subbasin declined nearly 50 percent between 1954 and 1969, however the value of dairy products sold has shown a steady increase. The value of return per head in 1964 was $254, twice as great as it was in 1954. The price of milk paid to farmers increased less than 5 percent.

In summary, agriculture is the basic industry of the area with manufacturing playing an increasing role in the economic activity of the area. In 1970, rural population was greater than urban population in the subbasin. In 1960, agricultural employment was greater than any other area of employment. The value of all farm product sales is greater than the value added in manufacturing. Economic growth of the area is indicated by the increased production in both agriculture and manufacturing.

4. Forest Resources and Related Economic Activities

A. Extent and Nature of the Resources

Aerial extent of forests is shown, by county, in Table 4.13.

Volume of growing stock and sawtimber on commercial forest land, by counties and species classes is shown in Table 4.14.

Prior to settlement, most of the Blue Earth Subbasin was in a prairie type vegetation which was maintained by buffalo grazing and fire. Therefore, trees, mainly oak, ash, elm, maple, basswood and cottonwood, were usually confined to

Table 4.12

Major Livestock Enterprise, 1954, 1959, 1964 and 1969[1/]
Blue Earth River Subbasin, Minnesota

	1954	1959	1964	1969
Livestock on Farms				
Cattle and calves	236,840	259,743	271,660	216,145
Milk cows	65,105	50,650	50,736	32,466
Hogs and pigs	633,611	649,791	507,769	742,525
Sheep and lambs	84,676	87,022	63,575	43,875
Chickens - 4 months old or older	2,983,400	2,485,347	1,488,327	430,105
Value of Livestock and Livestock Products Sold				
Cattle and calves ($1,000)	16,139	37,277	34,940	*
Hogs and pigs ($1,000)	26,732	24,090	23,750	*
Sheep and lambs ($1,000)	926	919	950	*
Any milk or cream ($1,000)	8,294	10,646	12,888	*
Poultry and poultry products sold ($1,000)	9,144	8,718	7,912	*
Other livestock or livestock products	232	223	704	*
Quantity of Livestock and Livestock Products Sold				
Cattle and calves	115,097	182,451	194,882	180,686
Hogs and pigs	644,447	802,985	791,884	742,525
Sheeps and lambs	57,894	61,253	55,325	40,845
Broilers and meat-type chickens	1,538,332	1,527,418	1,128,716	881,563
Turkeys and turkey fryers		541,799	557,652	*
Eggs (1,000 doz.)	21,670	23,732	19,027	*
Whole milk (1,000 lbs.)	131,943	327,557	381,312	*
Wool (lbs.)	400,634	410,910	398,551	*

1/ U. S. Department of Commerce, Bureau of Census, Census of Agriculture, 1954, 1959, 1964 and 1969.

* Unavailable at time of writing.

Table 4.13

Area of Land and Commercial Forest Land by Counties
Blue Earth River Subbasin, Minnesota and Iowa

County	Total Forest Area in County/in Basin	Forest Land in Basin Non-Commercial	Commercial
	acres	acres	acres
Blue Earth	33,300/25,200	1400	23,800
Brown	15,800/1,500	100	1,400
Cottonwood	7,100/2,100	100	2,000
Faribault	13,600/13,600	800	12,800
Freeborn	16,400/3,500	200	3,300
Jackson	6,800/800	100	700
LeSueur	31,200/1,600	100	1,500
Martin	7,200/5,500	300	5,200
Steele	10,500/900	100	800
Waseca	12,300/9,900	600	9,300
Watonwan	5,400/5,400	300	5,100
Emmet, Ia.	4,000/100	0	100
Kossuth, Ia.	8,000/1,900	0	1,900
Winnebago, Ia.	3,000/500	0	500
TOTALS	174,600/72,500	4,100	68,400

Table 4.14

Volume of Growing Stock and Sawtimber
on Commercial Timber Land by County
Blue Earth River Subbasin, Minnesota and Iowa

County	Growing Stock* Thousand Cubic Feet	Sawtimber** Thousand Board Feet
Blue Earth	14,621	75,352
Brown	863	3,732
Cottonwood	1,663	8,433
Faribault	6,525	32,750
Freeborn	2,134	8,128
Jackson	523	2,759
LeSueur	764	3,514
Martin	1,890	8,473
Steele	454	2,089
Waseca	4,605	18,146
Watonwan	2,030	9,220
Emmet, Ia.	77	213
Kossuth, Ia.	1,654	4,752
Winnebago, Ia.	326	1,332
TOTALS	38,129	178,893

* Growing stock is about 98% hardwoods and 2% softwoods.

** All hardwood sawtimber - there is no softwood sawtimber.

valleys and river bottoms. During settlement (1840-1880) buffalo grazing and wild fires were greatly reduced. Woodlots were planted in and around homesteads for firewood, shade and shelter. These (human) influences actually increased the total area of forest lands until the 1940's when it became profitable to clear some of the original and the man-made or protected forest stands and convert the land to agricultural use.

This extract from "The Forest Resources of Southwestern Minnesota" describes the commercial timber species and volumes.

> "The bottomland hardwood is the largest type covering 42% of the commercial forest area. The two most predominant species in this type are American elm and green ash which make up 54% of the total volume. The remainder of the volume is in miscellaneous species such as willow, silver maple, basswood, slippery elm, etc.
>
> "The oak type is second largest with 22% of the commercial forest area in this type. Bur oak predominates with 63% of the volume with red oak next with 15% of the volume. The rest of the oak type is made up of miscellaneous species such as American elm, basswood and white oak.
>
> "The northern hardwood type covers 10% of the commercial forest area. Basswood is the predominant species with 51% of the total volume, followed by slippery elm 9%, red oak 9%, American elm 8%, bur oak 7%, sugar maple 6%, and the remaining volume in miscellaneous species."

B. Utilization of Forest Resources

The kinds, volumes and values of forest products produced in this subbasin are shown in Table 4.15. Current available data on employment in wood production and processing is presented in Table 4.16.

Black walnut trees growing in the subbasin can provide a high value forest product. Approximately 393 thousand board feet (MBF), valued at $216,150 (1971 prices) are harvested annually from the subbasin. About 90% of this harvest leaves the state in log form to be processed into veneer furniture, and other high value products. All of these are processed outside of the subbasin and, in many cases, outside of the United States. These black walnut trees are so valuable that occasionally they are literally

Table 4.15

Kinds, Volumes and Values of Forest Products
Produced Annually
Blue Earth River Subbasin, Minnesota and Iowa

Kinds of Products	Volumes	Sale Values*
Black Walnut Logs	393,000 board feet	$216,150**
Mixed hardwood logs**	2,330,000 board feet	$ 58,250**
Wood pallets and miscellaneous products***	50,000 pallets	$199,200
Millwork****	various items	$812,970****
Resale of logs to buyers in and out of the basin	1,439,000	$442,187
Maple syrup	200 gallons	$ 1,300*****
Christmas trees	500 trees	$ 2,500*****
Firewood	30 cords	$ 1,050*****

* 1971 Prices

** Cottonwood, red maple, white oak, boxelder, hackberry, bur oak and red oak logs.

*** Crates, boxes, skids, dunnage, blocking.

**** Doors, sashes, churchwork, furniture, gunstocks.

***** Dollars paid to landowners.

Table 4.16

Employment and Income
Logging and Wood Processing
Blue Earth River Subbasin, Minnesota and Iowa

Type of Work	Number of Man Years Employed	Income
Logging	19.0	$123,500
Sawmilling	9.0	$ 72,000
Millwork	87.0	$696,000
Maple Sugar	0.1	*
Christmas Trees	0.1	*
Firewood	0.1	*
Log Wholesaling	2.0	$ 16,500
Total	117.3	$908,000

* Income shown in Table 4.15.

stolen from the landowner. More commonly, there is a history of walnut log buyers, offering landowners less than half of the current value of the standing tree. Landowners can be assured of receiving a fair price for their timber by consulting their District Forester from the Minnesota Department of Natural Resources. The name, address and phone number of the forester serving each county in the subbasin is shown in Table 4.17.

Other timber species such as cottonwood, red maple, white oak, box elder and hackberry are locally processed into pallets. The average annual harvest of these mixed hardwood species amounts to 2,330,000 board feet. Landowners receive annually, $58,250 from timber sales and stumpage fees.

Revenue to loggers and brokers from the resale of logs cut from the subbasin is $442,187.

Three manufacturers in the subbasin process 777 thousand board feet of wood grown entirely outside the subbasin into finished doors, sashes, furniture and church work. Secondary processors in the subbasin consume 2,479,000 board feet of logs each year to produce $1,012,170 worth of finished products. About 70% of the logs come from the subbasin.

Three landowners collect and process 200 gallons of sugar maple sap into syrup each year. This provides about $1,300 gross income.

Christmas trees are grown and sold, about 500 trees per year, for a gross income of about $2,500.

Three operators cut and sell fireplace wood. Approximately 30 standard cords are cut each year and sold for a gross income of $1,050.

Each year these industries provide employment equivalent to 117.3 man years. Personal income from this work averages about $908,000 per year.

Floodplain forest lands are an important source of hardwood timber. Productivity of these sites are high due to periodic floodwater fertilization and abundant soil moisture. A few of the more economical species are American elm, red elm, green ash, silver maple, box elder and cottonwood. Certain species should be favored on the basis of marketability, insect and disease problems, and response to management. A forester can be consulted on whether to grow the fast growing cottonwood, the better formed ash and maple, or the more abundant elm. At the present, elm is an academic

Table 4.17

Names, Addresses and Telephone Numbers
of Minnesota Department of Natural Resources Foresters
Serving Minnesota Counties Included in the
Blue Earth River Subbasin

Name	Address/Phone Number	Counties Served
Jerry Langworthy	104 E. Liberty Street Mankato 56001 507-387-2114	Brown, Blue Earth, Watonwan, Faribault, Martin
Dave Anderson	E. College Drive Marshall 56258 507-532-3859	Cottonwood, Jackson
Bill Schmidt	Box 195 303 A Central Avenue Faribault 55021 507-334-8190	LeSueur, Waseca, Steele, Freeborn

topic as it is passing out of the picture due to Dutch Elm Disease. Wood products manufactured from these species include paper, lumber, veneer, baseball bats, vehicle parts, furniture, pallets, crates and baskets. The combination of high productivity and a varied market demand assures a good return on floodplain forest investments.

Several forest resources which are not presently quantified contribute to the economy of the Blue Earth Subbasin.

In and around Mankato some forested lands are desirable for homesites. These sites can be "landscaped" by merely removing some vegetation. This is less expensive than transplanting large trees and shrubs onto the site. Also, the existing vegetation is larger and provides more shade and protection than large, transplanted trees could. Wooded homesites usually sell for 50-100% more than homesites on cleared land. Shade trees are roughly appraised in dollar value by assuming $7.00 per square inch of basal area (cross-sectional area of the tree 4.5 feet above ground).

Another considerable (qualitative) value of forest lands is their appearance. The vast areas of relatively flat, cultivated lands are monotonous to most people. The variety which forests lend to this landscape is an important contribution to the quality of life in this area. In and around recreation areas such as Sibley Park in Mankato, Minneopa Park, West of Mankato, the chain of lakes around Fairmont, and resting spots along highways, the presence of trees, shrubs and other more permanent, forest-type vegetation makes the areas much more enjoyable.

Forest lands comprise most of the cover for wildlife in this basin. Song birds are the major species remaining. A few pheasants winter over successfully in and around villages. Wetlands and floodplains usually offer sufficient cover especially where these areas are forested.

Many forest lands are essentially confined to the river bottoms and steep slopes. Much of the land is unsuitable for agriculture and is consequently undeveloped. These floodplain forests can contribute many social and economic benefits to the local people. Many of these floodplain associated benefits could be realized if these areas are developed as environmental corridors. This would assure their usefulness for recreation, forestry and wildlife. Furthermore corridors serve as a form of floodplain zoning and thereby reduce local flood damages. Economic gain will be realized on both the direct and indirect goods and services provided in utilizing these floodplains. A few of

the industries that will benefit are the sporting goods, watercraft, gasoline/transportation, tourist, photography, snowmobile, camper trailer and equipment rentals.

C. Current and Projected Growth

The further development of forest industries in this subbasin obviously depends on the supply of land, labor and capital. The availability of markets for the forest products is an equal factor.

The present forest industries in the subbasin could, at least, stabilize over the next fifty years if all lands not suitable for cropland, pasture, commercial or residential development were managed for multiple uses of recreation, wildlife, watershed protection and timber production. With intensive land management to maximize forest production from each available acre these industries could be enlarged.

D. Employment and Income in Related Trade and Service Industries

Using the data developed by Dr. Dwight Hair, it is estimated that for every person currently engaged in primary production of forest products 5.65 additional jobs are produced. There are nine people engaged in primary production of forest products in this subbasin. This generates fifty additional jobs and approximately an income of $400,000.

V. WATER AND RELATED LAND RESOURCE PROBLEMS

Water and land resource problems stem from man's demands on the resources to provide the basic elements of his existence. The Blue Earth River Subbasin has a large natural land resource of productive soils. The total water supply is plentiful, but still a scarce resource in terms of availability at the proper time and place. A lack of understanding regarding the capabilities of the resources has been a basic problem resulting in the waste of our resource base. The restoration and conservation of natural resources has become a real concern at every level of society.

Problems identified thus far in the Blue Earth Subbasin include:

(1) Agricultural damage from flooding on about 28,000 acres.
(2) Extensive wetness condition on 613,500 acres of cropland.
(3) Roadside, streambank, and lake shore erosion causing sedimentation problems.
(4) Accelerated pollution of many subbasin lakes and streams.
(5) Possible future water supply shortages.
(6) Some areas of the subbasin have droughty soils needing supplemental irrigation to make high yield crop production possible.
(7) Deterioration of the natural environment.

A summary of the specific problems in the subbasin that were reported by local officials can be found in Table 5.1.

1. Floodwater

A. Agricultural Cropland and Pasture

Flooding of agricultural land in the subbasin is a cause of concern in numerous localized areas throughout the subbasin.

Flooding associated with spring snowmelt is quite extensive over the floodplains. Flooding of this type, however, does not cause the damage which results when summer storm runoff causes flooding of growing crops. The greatest problems from spring snowmelt flooding result when field cultivation and planting are delayed because of increased dry out time for the soil. Research increasingly sustains the theory that reduced yields result for each day planting is delayed beyond a given optimum date.

The effect of this type flooding may extend beyond the land inundated adjacent to the channel in that tile drainage systems cannot function when outlets are flooded. Therefore, the increased drying time may result on lands not flooded but effected by the temporary inefficiency of the drainage system.

Table 5.1 - Summary of Problems, Blue Earth River Subbasin

County	PROBLEMS							
	Flooding	Drainage	Irrigation	Water Supply	Water Quality	Lake Level Reg.	Recreation Fish & WL	Erosion & Sediment
Watonwan	St. James Cr.	Needed	Good	City of	Watonwan R.	-	Kansas Lk.	-
	Watonwan R.		Potential	St. James		-		-
	Spring Branch				St. James Cr.	-		-
	Butterfield Cr.							
Faribault	Maple River	Needed	-	-	E.Fork B.E. R.	Minnesota Lk.	Minnesota Lk	Blue Earth
	Blue Earth R.		-	-	Blue Earth R.	Walnut Lake	Walnut Lake	River Tribs
Cottonwood	Watonwan R.	Needed	-	-	Bingham Lk.	Mountain Lk.	Fish Lk.	-
	Elm Creek		-	-	Mountain Lk.	-	-	-
Jackson	Elm Creek	Needed	-	-	-	-	-	-
Blue Earth	Blue Earth R.	Needed	-	-	Madison Lk.	Minnesota Lk.	Minnesota Lk	Blue Earth
	Maple River		-	-	-	Madison Lk.	Madison Lk.	River
	Cobb River		-	-	-	-	-	-
Brown	Watonwan R.	-	-	-	-	Hanska Lk.	-	-
LeSueur	-	-	-	-	Madison Lk.	Madison Lk.	Madison Lk.	-
					Elysian Lk.			
Waseca	LeSueur R.	-	-	-	Elysian Lk.	-	-	-
	Little Cobb R.	-	-	-	-	-	-	-
	Cobb River	-	-	-	-	-	-	-
Martin	Elm Creek	Needed	-	-	Fairmont Lks	Fairmont Lks.	-	Dutch Cr.
	Center Cr.	-	-	-	Center Cr.	-	-	Fairmont
								Lakes
Freeborn	LeSueur R.	Needed	-	-	At Freeborn	-	-	-
	Cobb River		-	-	-	-	-	-
	Foster Cr.		-	-	-	-	-	-

Floods caused from excessive runoff during the growing season may result in the total loss of crops on the floodplain. Investigations made in the Blue Earth Subbasin show that approximately 28,000 acres of crop and pastureland may be affected by this type of flooding (See Figure 5.1). The shaded areas on the map represent the location and approximate size of these flood problem areas. The acre figures recorded on the map represent the estimated area flooded from summer storms.

Table 5.2 shows the watershed name, county, number of acres, and the land use on these flood damage areas in the subbasin.

2. Agricultural Drainage

One of the most controversial subjects today is agricultural drainage and its effect on fish and wildlife habitats and downstream flooding. The Blue Earth River Subbasin is primarily an agricultural region where drainage improvement has been necessary for economic development. The reason all counties in the subbasin have had a history of extensive channel improvement and tile installation is because geologically the area is not old enough for nature itself to have formed the stream drainage patterns.

Whether drainage has increased downstream flooding is highly debatable. It can be argued one way that drainage speeds up runoff. It can be argued convincingly another way that tile systems and the required channel outlets greatly reduce soil moisture content which creates a tremendous volume of available flood storage in the soil itself. It is an established fact that many wetlands have been drained which has decreased wildlife habitat.

This Inventory Report does not intend to recommend what should be done now or planned for the future in regard to drainage. The following information, it is hoped, will provide facts that will assist the Southern Minnesota Rivers Basin Commission and participating agencies in properly considering drainage problems and determining what should be done about them.

Almost without exception every County Board and Soil and Water Conservation District stated in a questionnaire that more agricultural drainage improvements were needed in their county. The Minnesota Inventory of Soil and Water Conservation Needs (CNI) reported over one million acres in the Blue Earth Subbasin that had water (drainage) problems. Adequate drainage systems are needed on 613,500 acres of cropland according to the 1967 CNI.

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

LOCATION AND AREAS OF CROPLAND AND PASTURE DAMAGED BY FLOODING

Study Area 1 - BLUE EARTH RIVER SUBBASIN

of the

MINNESOTA RIVER BASIN

portion of the

SOUTHERN MINNESOTA RIVERS BASIN STUDY

MINNESOTA, SOUTH DAKOTA, AND IOWA

SOURCE:
AMS 1/250,000 TOPOGRAPHIC MAPS, MINNESOTA AND IOWA COUNTY HIGHWAY MAPS AND INFORMATION FROM THE FIELD TECHNICIANS.

FIG. 5.1 5,S-29226

Table 5.2

Agricultural Flood Damage Areas by County
Blue Earth River Subbasin

County	Watershed - CNI#	Acres (Damage)	Land Use - %		
			Crop	Pasture	Other
Freeborn	LeSueur River 8e2-01	150	75	20	5
	Cobb River 8e2-07	100	85	10	5
	Foster Creek 8e-12	75	75	20	5
Blue Earth	Cobb River 8e2-07	100	20	20	60
	Cobb River 8e2-07	200	40	40	60
	Cobb River 8e2-07	300	70	20	10
	Little Cobb River 8e2-06	150	85	10	5
	Maple River 8e2-11	400	50	45	5
	Maple River 8e2-11	100	95	5	0
	Blue Earth River 8e-03	160	75	10	15
	Blue Earth River 8e-03	500	75	20	5
	Blue Earth River 8e-03	200	75	15	10
	LeSueur River 8e2-01	200	75	20	5
Waseca	Little Cobb River 8e2-06	200	20	40	40
	LeSueur River 8e2-01	400	90	5	5
Brown	Lake Hanska 8e1-04	500	30	60	10
	Linden School Lakes 8e1-05	300	30	60	10
Jackson	Elm Creek 8e-17	700	18	70	12
Martin	Elm Creek 8e-17	2000	80	20	0
	Cedar Lake 8e-16	1000	40	40	20
Cottonwood	Bingham Lake 8e1-06	1500	90	5	5
	North Fk. Watonwan R. 8e1-07	2000	70	20	10
Watonwan	St. James Creek 8e1-03	640	25	55	20
	Butterfield Creek 8e1-02	860	40	40	20
	Spring Br. Creek 8e1-11	380	65	25	10
	U. Watonwan River 8e1-01	8000	70	20	10
	Perch Creek 8e1-12	150	30	45	25
	South Fk. Watonwan R. 8e1-09	4000	70	20	10
Faribault	Blue Earth River 8e-03	1200	20	10	70
	Badger Creek 8e-10	200	50	25	25
	Elm Creek 8e-17	200	50	10	40
	East Fk. Blue Earth R. 8e-13	500	25	10	65
	Maple River 8e2-11	520	75	5	20
	Foster Creek 8e2-12	100	90	10	0

The following basin description and accompanying map are presented to further define the drainage situation and problems.

A. Blue Earth River Subbasin Land Drainage Development

(1) Related Features

a. The Land Surface

In geologic age the land surface equates with the more recent surfaces on the earth's surface. Briefly, it is glacial drift deposits emplaced on level bedded underground strata. Most irregularities were further subdued by the drift emplacement. Relief differences are dominantly within 10 to 20 feet but range from 5 on the lake plain to several hundred along the stream entrenchments. Most landforms had a common feature: namely, a low gradient, unincised drainage net above the major streams.

b. History

Drainage development was one of the prime capital investments into the orderly development of the drainage basin. Drainage development into this area was an extension of methods developed and applied to similar needs in Indiana, Illinois, and Iowa.

The improvement of outlets began in the early 1880's. Tile drainage began about 1910. Drainage development has evolved to where most of the outlet ditches have been installed and tiling systems are being improved and extended.

c. Climate

Annual precipitation ranges from 26 to 28 inches from west to east. Most crops use 15 to 20 inches water. Four inches is near the modal runoff. The difference is stored in the soil. Solar energy maximum is not in concert with the maximum plant growth of the dominant crops. Hence, drainage is the prime management input to improve soil-climate relationship. Planting and harvesting is severely limited to April 15th to November 15th in most years.

d. Plant Growth

Biological zero is about 40 degrees Fahrenheit. Grains germinate at 50 degrees Fahrenheit. Corn germinates at 55 degrees Fahrenheit. Roots of the prime crops do not extend into a saturated soil. Solar heating efficiency is 4 to 5 times less on a water saturated soil than on a soil at optimum moisture.

e. Drainage Design

Most drainage ditches are constructed for the purpose of tile outlets. Grades are designed to be non erosive. Ditches are a minor part of the landscape. Excess soil water is removed through tile. Design removal rates are 3/8 inch or less per 24 hours.

f. Drainage Patterns, Designs and Maintenance by Physiographic Areas (For delineation of physiographic areas, see Figure 5.2)

(1) Area 1

This area has ample grade opportunities for tile installations. Constructed outlet channels are few. Tile installation has not been as extensive as in other parts of the subbasin. The soil pattern commonly dictates a random pattern for tile systems.

(2) Areas 2, 4 and 9

This area had marginal grade opportunities for channel development for tile outlets. Adequate tile systems outlet depth are commonly attained by channel construction or improvement of considerable length. Unless some favorable natural outlet is available, channels have marginal tile outlet depth in the lower reaches or in the depressions. Most of the perched water and much storm water is delivered to the outlet channel through tile.

Tile pattern ranges from grid type in the larger poorly drained soil areas to random on the poorly drained soils within the knolls. Tile systems are commonly designed for a 100 foot interval and 3 to 4 foot depth. Some

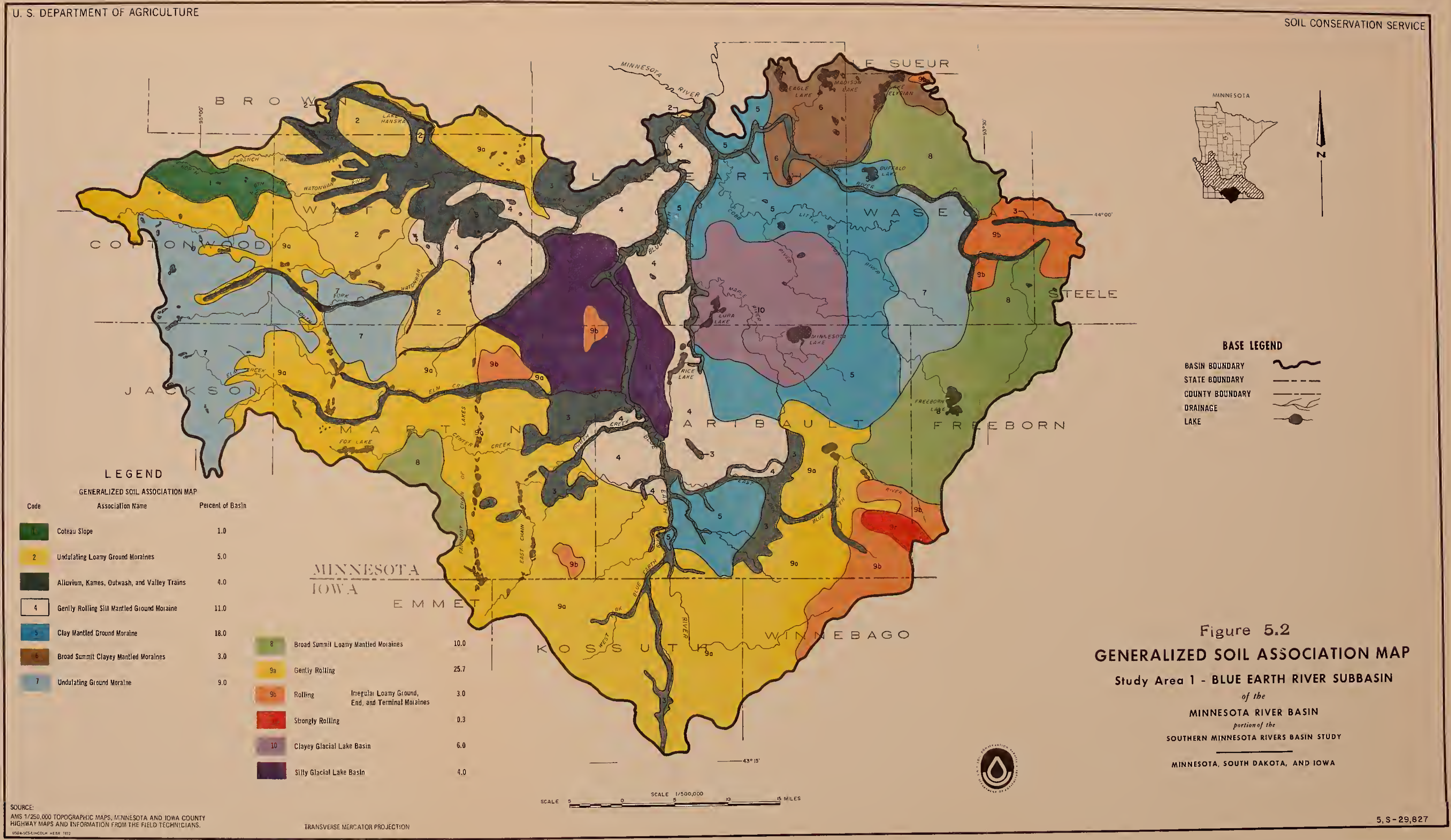


Figure 5.2
GENERALIZED SOIL ASSOCIATION MAP
Study Area 1 - BLUE EARTH RIVER SUBBASIN
of the
MINNESOTA RIVER BASIN
portion of the
SOUTHERN MINNESOTA RIVERS BASIN STUDY
MINNESOTA, SOUTH DAKOTA, AND IOWA

areas are designed for open inlets in depressional areas, others are not.

Channel maintenance is a periodic need. Freezing and thawing, wetting and drying produces sideslope slump that affects the critical grade margins in time.

(3) Area 3

Most of these areas are adjacent to natural streams and water management varies by local area. A few areas depend on diking or diking and pumping. Some have natural streams with ample tile outlet opportunities. Some benefit from channel improvement.

Tile patterns range from grid type to random systems. Tile systems are designed for 100 to 200 foot intervals and 3 to 4 foot depth. Closer spacings will probably be common in the near future.

Channel maintenance is a periodic need. The sandy sideslopes are unstable. Tile grades are a critical factor. The fine sands in the subsoil of some areas enter and fill tile installed on a nearly level grade.

(4) Areas 5, 7, 10 and 11

These areas have marginal grade opportunities for channel development for tile outlets. Adequate tile systems are commonly dependent on outlet depth attained by channel construction of considerable length. Unless some favorable natural outlet is available, channels have marginal tile outlet depth in the lower reaches or in the depressions. Most perched water and much storm water is delivered to the outlet channel through tile.

Tile patterns are dominantly grid type. Tile systems are commonly designed for 80 to 100 foot intervals and 3 to 4 foot depth. 100 foot intervals are most satisfactory in area 7. 80 to 90 foot intervals are more satisfactory in areas 5, 10 and 11. Areas 5, 10 and 11 have many small shallow depressions of Barbert soils that need open inlets or french drains

for satisfactory drainage. Closer spacings will probably be common in the near future.

Channel maintenance is a periodic need. Freezing and thawing, wetting and drying produce sideslope slump that affects critical grade margins in time.

(5) Areas 6 and 8

These areas have several kinds of outlet opportunities. The broad summits commonly have ample outlet opportunity. The greater the relief difference, the greater the opportunity. The broad lower levels have adequate grade levels in some areas and others need extensive outlet development or dikes and pumps. Some outlet opportunities are preempted by lake levels. Outlet channels commonly cross peat bogs of various sizes. Flooding adjacent to the channel is a greater hazard than in other areas.

Tile patterns range from grid type to random systems. Closer spacing design is needed in area 6 than in area 8.

Channel maintenance is a periodic need. Freezing and thawing, wetting and drying produce sideslope slump that affects the critical grade margins in time.

These areas offer more opportunity for multiple use than the other areas in the subbasin.

3. Erosion and Sedimentation

An inventory was made by the Soil Conservation Service to determine the location and extent of various types of erosion in the Blue Earth Subbasin and the resultant sedimentation effects on the environment. The types of erosion cataloged were roadside erosion; streambank erosion, including natural and constructed channels; lake shore erosion and critical erosion areas such as gullies and gravel pits. The results of this inventory are as follows:

(1) Roadside erosion

There are 36 miles of roadside erosion, 31 miles of which are contributing sediment to streams.

(2) Streambank erosion

There are 200 miles of streambank and channel erosion all of which contribute sediment directly to streams.

(3) Lake shore erosion

Twenty three miles of raw lake shore, where erosion is taking place, contributes sediment directly to lakes.

(4) Critical erosion areas

Critical erosion is occurring on about 5500 acres of land. 2700 acres of this land is contributing sediment to streams and lakes. 1000 acres of gravel waste are exposed, about 930 acres of which is within a closed basin and does not contribute sediment outside of the area.

Sheet erosion is critical in some areas although not considered serious in the subbasin as a whole. Erosion on cropland occurs when excess rainfall causes water to run in "sheets", picking up sediment and transporting it until the water is ponded or until the velocity is reduced sufficiently to drop the material. The amount of material that does not drop out enters streams or lakes and is termed sediment yield. The total yield from all sources in the Blue Earth Subbasin is estimated to vary from 40 to 150 tons per square mile per year depending on drainage area, soil type, length and steepness of slope, land use, vegetal cover, past and present land management and the conservation practices installed. In comparing the entire subbasin with others nation-wide the sediment yield is considered low although some areas yield moderate to high amounts.

Sediment damages on agricultural land is slight. Normal sediment deposited on the floodplains are silts and fine sands only a fraction of an inch thick. Such deposition is damaging when it occurs in homes and on furnishings. Heavy concentration of sediment in the streams pollute the water, damage fish habitat, and reduces the use of the stream for swimming, water supply, and other uses.

4. Pollution

A. Sources and Types

Pollution of the waters of lakes, marshes and streams is the major type of pollution in the subbasin. Major sources of pollution include municipal, industrial and agricultural wastes. Another source believed to be serious is from farmstead septic tanks that discharge into tile drainage systems.

Although agricultural wastes are thought to be the major source, the extent of agricultural pollution is not readily determinable. Agricultural pollution differs from municipal and industrial pollution in two important ways. First, municipal and industrial wastes generally originate in relatively localized centers of concentrated population and within the relatively small confines of individual industrial plants, whereas agricultural wastes originate over extensive tracts of land. Secondly, municipal and industrial wastes issue into plumbing structures for disposal to and through sewage systems to treatment facilities and to points of continuous discharge to lakes or streams.

Pollution from agricultural sources, however, is often the unavoidable consequence of rainfall. When rainfall is sufficiently heavy, pesticides (including herbicides, insecticides and fungicides) are washed from plant surfaces. They then combine with fertilizers and soil and are carried by surface runoff or through drainage tile and into the lakes, marshes and streams. Similarly, animal wastes are often dispersed by rainfall and carried by runoff water to lakes, marshes and streams.

Although the extent of pollution from pesticides and fertilizers is not readily determinable the <u>potential</u> for pollution from this source is great due to the high intensity of farming in the subbasin. The <u>potential</u> for pollution from animal waste is also great since animal wastes are not generally controlled and animals produce much more waste per unit than humans. The population equivalent of the wastes of animals within the subbasin approaches 2 million as compared to a 1960 human population of about 115,000.

Municipal wastes produced are small in comparison to the potential agricultural and livestock wastes. Four communities within the subbasin, Good Thunder, Bricelyn, Easton and Lewisville, with a combined 1960 population of 1,620, discharge untreated wastes into the streams. Two other communities, Amboy and Vernon Center, discharge sewage into streams after only primary treatment. Thus a need now exists to increase the amount of treatment at these communities.1/

Pollution from industrial sources is limited primarily to industries which process farm products. Creameries, meat lockers, rendering plants, packing plants and canning factories that are not connected to municipal systems may discharge inadequately treated wastes into streams during certain periods of the year.

1/Appendix F, Interim Survey Report on the Blue Earth River, Minnesota, St. Paul District, Corps of Engineers.

Pollution in most of the lakes results in excessive algae growth caused by nutrients carried by runoff water. The pollution problem in streams is expressed by unsightly solid materials, unnatural color and offensive odors with the resultant lack of sufficient oxygen to support plant and animal life.

County Commissioners, Soil and Water Conservation District Supervisors, and SCS District Conservationists were asked to list the lakes and stream reaches that they considered to be polluted. Following is a summary of their reports by county:

(1) Blue Earth County

All of the lakes in the county are polluted quite badly from various sources including human and livestock wastes, pesticides, fertilizers and sediments. Some of the major lakes that are polluted to the degree that they are losing their value for recreation are; Eagle, Madison, Lura and Minnesota Lakes. The Blue Earth, LeSueur, Cobb and Watonwan Rivers become polluted during periods of low flow. There was a significant amount of fish kill in these rivers in 1962 and 1967.

(2) Brown County

Lake Hanska has an excessive algae problem caused by wastes from livestock and other agricultural sources.

(3) Cottonwood County

Mountain Lake has a severe algae problem. Septic tanks around the lake, feedlot, and other agricultural wastes are believed to be the major sources. Bingham Lake also has an algae problem and is possibly receiving detergents as evidenced by the foam along the shoreline. Fish Lake is being polluted from septic tanks and has an algae problem.

(4) Faribault County

Bass Lake is polluted from lake shore development and lake shore erosion. East Rice Lake has a severe algae problem and is polluted so badly that it has lost its value for fishing and swimming. The Blue Earth River from Section 20 in Blue Earth Township to Section 24 in Verona Township is highly polluted from feedlot and

rendering plant wastes. It is also polluted from Section 3 in Verona Township to Section 3 in Winnebago Township by vegetable canning factory wastes. Brush Creek is polluted from vegetable canning factory wastes in the lower 3 miles.

(5) Freeborn County

The village of Freeborn discharges untreated wastes into a group drainage ditch east of the village.

(6) Martin County

The Fairmont chain of lakes have a serious algae problem. The local people feel that the Dutch Creek Watershed is one of the major sources of nutrients. Many other lakes in the county also have excessive algae growth. Center Creek east of Fairmont is polluted from feedlot and canning factory wastes.

(7) Waseca County

Lake Elysian, the largest lake in the county, is polluted from feedlot wastes, septic tanks, industrial wastes and shoreline development. Other lakes reported to be polluted from various sources include, St. Olaf, Rice, Reeds, Lily and Buffalo.

(8) Watonwan County

St. James Lake is unsuitable for recreation use due to pollution from stockyards in St. James and from other sources. St. James Creek is polluted downstream from St. James. One of the sources may be a poultry packing plant. The Watonwan River is polluted downstream from Madelia. Possible sources include a poultry packing plant and metal plating industry. It was also reported that the city sewage treatment plant at Madelia does not always operate efficiently.

(9) Kossuth County, Iowa

Burt Lake in the northwest corner of the county is highly polluted from feedlot wastes.

(10) Winnebago County, Iowa

The village of Rake (population 300) in the northwest part of the county has individual septic tanks which discharge directly into a county tile system. This effluent causes pollution along about three miles of open channel downstream from the village.

B. Effects of Pollution

The effects of pollution as a hazard to human health or the killing of fish, wildlife or other living organisms is not known in quantitive terms. Of general concern is the increased destruction of the recreation and aesthetic value of the surface waters in the subbasin. Pollution of surface water also reduces the value of property adjacent to it. Several lakes have lost their value for swimming and fishing as well as their scenic beauty.

One of the more serious problem areas is the excessive algae growth in the Fairmont chain of lakes. Homes in the city of Fairmont (population 12,000) as well as parks and other recreation areas which surround the lakes are losing value due to the deterioration of the lakes. In addition, the city uses Budd Lake as a source of municipal water and water treatment costs continue to rise. The city has spent 15 to 20 thousand dollars a year for copper sulphate to control algae growth. The program has had limited success since the amount of copper sulphate necessary to control algae growth kills the fish. Fairmont is also dredging their lakes to remove sediment and organic material. This will increase the depth and capacity and tend to dilute the nutrients that enter the lakes.

5. Recreation - Problems and Needs*

6. Fish and Wildlife - Problems and Needs*

*Investigations are being made by the Soil Conservation Service. Studies need to be coordinated with state and federal agencies.

7. Water Supply

A. Rural Domestic and Livestock

The only area reported to have a water supply shortage for rural domestic or livestock use is in Delton Township in Cottonwood County. Farmers have a problem digging wells due to the Sioux quartzite rock. Farm ponds solve most of the present needs.

B. Municipal and Industrial

There are presently no water supply problems for municipal or industrial use. The sustained groundwater capacity is expected to be adequate to meet the projected water supply needs at nearly all of the communities within the subbasin up through the year 2020, however, detailed projections of demand and availability need to be made.

8. Forest Protection - Problems and Needs*

9. Irrigation

The Blue Earth Subbasin is similar to most areas of the upper midwest in that rainfall patterns, amounts, distribution, and time of occurrence are erratic. In most years, there are usually periods during the growing season when rainfall is not sufficient to replenish soil moisture for optimum crop growth. Consequently, it is during these periods of shortages that supplemental irrigation is needed.

Furthermore, not all rainfall is effective. Effective rainfall is that part of the total rainfall which does not run off, but enters the soil and is available for plant use.

Nearly 30,000 acres of agricultural land within the subbasin have soils with low water holding capacity (see Figure 5.3). Consequently, a localized need exists to improve yield on these droughty soils - possibly through irrigation. A problem with irrigation exists in that high level management is required to insure profitability from an irrigation system investment.

*Investigations are being made by the Forest Service. Studies need to be coordinated with state and federal agencies.

U. S. DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

Figure 5.3

GENERALIZED IRRIGABLE LAND AREA

Study Area 1 - BLUE EARTH RIVER SUBBASIN

of the

MINNESOTA RIVER BASIN

portion of the

SOUTHERN MINNESOTA RIVERS BASIN STUDY

MINNESOTA, SOUTH DAKOTA, AND IOWA

SOURCE:
AMS 1/250,000 TOPOGRAPHIC MAPS, MINNESOTA AND IOWA COUNTY HIGHWAY MAPS AND INFORMATION FROM THE FIELD TECHNICIANS.

TRANSVERSE MERCATOR PROJECTION

USDA-SCS-LINCOLN NEBR 1972

5, S-29,819

10. Relationship of Water Problems and Needs to the Impairment of Natural Beauty

The natural beauty of many of the lakes in the subbasin is being impaired by the excessive growth of algae. Although algae bloom is a natural biologic process it is believed that the process is being accelerated by the more intensive farming practices and increased municipal and industrial wastes which supply more nutrients to the runoff water which enters the lakes and promotes algae growth.

VI. FEDERAL AND STATE WATER AND RELATED LAND RESOURCE PROGRAMS

Many water and related land resource programs are available through state and federal agencies. The major United States Department of Agriculture Agencies participating in the Southern Minnesota Rivers Basin study are the Soil Conservation Service, the Forest Service and the Economic Research Service. Other USDA Agencies involved in such studies include the Farmers Home Administration, the U. S. Extension Service and the Agricultural Stabilization and Conservation Service. The U. S. Corps of Engineers has had and continue to have a great deal of interest in the land and water developments of the Southern Minnesota Rivers Basin.

Strong state agency leadership and participation in a river basin study is a necessity if a truly comprehensive plan is to be developed. State and local input to a study makes possible the consideration of all interests to be served. By adequately analyzing these broad interests a water and land use plan can be formulated which reflects the necessary compromises to make the plan the most acceptable to the most people.

The following is a brief description of the programs being carried on by the various agencies and groups mentioned above.

1. Soil Conservation Service

The Soil Conservation Service is a technical land use planning agency of the U. S. Department of Agriculture, responsible for developing and carrying out a national program of conservation and development of soil, water, and related resources.

The Service accomplishes these goals by providing technical assistance through local organized Soil and Water Conservation Districts to both rural and urban land users for all types of land use planning.

The Soil Conservation Service, which was created in 1935 by Public Law 46, has had a basic program of soil and water conservation since that time of providing technical planning and application assistance to land users, groups, and units of government as determined by priority established by the Soil and Water Conservation Districts.

Programs that the Soil Conservation Service has responsibility for or provides assistance on in this Blue Earth Subbasin include: conservation operations program, soil surveys, Public Law 566 small watershed program, river basin studies, conservation needs and technical on-site assistance in conjunction with the Agricultural Conservation Program. Most of these programs have a significant impact on soil, water, and related land resource conservation as well as resource development.

In doing this work, the Service believes that close cooperation with state and local governments and other federal agencies is a necessity to provide sound technical planning and resource development that is in line with the desires of the people and the state.

A. Land Treatment Program

The Soil Conservation Service, in cooperation with Soil and Water Conservation Districts, have assisted in installing numerous soil and water conservation practices on lands in the Blue Earth Subbasin. Soil and Water Conservation Districts are located in all of the counties in the subbasin. Soil and water conservation practices have an effect on the sediment yield and runoff yield from the watershed. Following are the quantities of soil and water conservation practices installed on the land within the Blue Earth River Subbasin. They are in excess of the following:

(1) Contour Farming - 6,150 acres
(2) Crop Residue Management - 14,700 acres
(3) Diversions - 3,800 lineal feet
(4) Grade Stabilization Structures - 357
(5) Grassed Waterways - 650
(6) Mulch Tillage - 94,000 acres
(7) Ponds - 53
(8) Structures for Water Control - 16
(9) Terraces - 328,500 lineal feet
(10) Wildlife Habitat Management - 958 acres
(11) Wildlife Wetland Management - 406 acres

It is also estimated that approximately 105,500 acres of the land in this subbasin is adequately treated from an erosion control standpoint.

This is a partial list of the major practices that will effect sediment and runoff. Many other practices have also been installed in the subbasin and the Soil Conservation Service feels that some impact will also be observed from these installations.

B. Soil Surveys

The Soil Conservation Service recognizes the value of providing up to date soils information. Following is a brief summary of progress in soil surveying in the Minnesota portion of the subbasin as of December 1971.

Soil surveys are complete in:

(1) Waseca County
(2) Steele County
(3) Freeborn County (or very nearly so)
(4) Faribault County (although this is old and should be updated)

Soil surveys will be complete in Blue Earth County by November of 1973. (Approximately 75% of the county has been completed).

In the remaining counties the survey work is limited. Progress in the remaining counties to date is as follows:

Martin County - 5% complete
Cottonwood County - None
Jackson County - 15% complete
Watonwan County - 30% complete
Brown County - 20% complete

No plans have been made to complete surveys in any of the above 5 counties in the near future.

A soil scientist requires approximately 75 man days (field time) to complete the soil survey of a township. This means that to complete the surveys in Watonwan County for instance, would require approximately 700 man days of soil scientist field time. The same kind of calculation can be made for the other counties provided one knows the amount of land in the subbasin.

Normally, soils are mapped on a county basis rather than following hydrologic watershed or river basin boundaries. The costs of this survey will range from $.50 to $.75 an acre depending upon a variety of contingencies. Soil Surveys have been accelerated and completed in several counties at their request and contribution of approximately 50% of the survey cost.

C. Resource Conservation and Development Program

In 1962 Congress passed the Food and Agriculture Act (Public Law 87-703) which authorizes the organization of Resource Conservation and Development projects.

A Resource Conservation and Development project is a locally initiated and sponsored activity to expand the economic opportunities for the people of an area. This is done by developing and implementing a plan of action for the orderly conservation, improvement, development and wise use of their natural resources.

In an RC&D project, Department of Agriculture assistance may be focused and extended to many diverse project measures involving and related to natural resources of the area. Technical and financial assistance can be provided by the Department of Agriculture for conservation measures which involve flood control, erosion control, agricultural water management, recreation and fish and wildlife development.

Local leaders are responsible for deciding if they want to develop and submit an application for planning assistance in development of an RC&D project plan. When they have decided to request this help, they are responsible for providing leadership at the local level, arranging for appropriate sponsorship, developing the application and for enlisting the help of SCS and other agencies that they may need in developing a project plan.

D. Public Law 566 Projects

Assistance to Soil and Water Conservation Districts and other qualified sponsors is available for developing group action projects through the Watershed Protection and Flood Prevention Act (Public Law 566). Applications for watershed planning assistance must be approved by the State Soil and Water Conservation Commission. The Soil Conservation Service has the job of administering the small watershed program. Projects are cost shared with federal, state and local funds. Sponsoring organizations receive assistance from the Soil Conservation Service, Fish and Wildlife Service, Farmers Home Administration, The Minnesota Department of Natural Resources and other agencies.

The Soil Conservation Service at the present time is involved in three Public Law 566 small watershed projects within the Blue Earth Subbasin (see Figure 2.2 and Table 2.1 for watershed location). They are as follows:

(1) The Janesville Village Watershed. This watershed has a drainage area of 108.4 square miles. Structural measures are planned as follows:

(a) 8 miles of multi-purpose channel improvement.
(b) 4 facilities for fish and wildlife purposes.

Construction within this watershed is anticipated to commence during the summer of 1972.

(2) The Upper Watonwan River Watershed has a drainage area of approximately 127,000 acres. The SCS is presently preparing a work plan for the development of flood control and wildlife improvement within the watershed. The following works of improvement are expected to be included within this work plan:

(a) 5 floodwater retarding structures.
(b) Approximately 30-40 miles of multi-purpose channel improvement.
(c) It is anticipated that there will be 2 or possibly 3 fish and wildlife improvement measures as part of the plan.

The present work schedule calls for the completion of planning efforts for this watershed before the end of calendar year 1972.

(3) The South Fork of the Watonwan River Watershed has a drainage area of approximately 129,900 acres. Local sponsors recently made an application to the State Soil and Water Conservation Commission for studies. This application has been accepted by the Commission and present preliminary information from SCS shows that a feasible Public Law 566 type watershed project can be developed for this watershed. It is not expected that there will be any channel improvement proposals within this watershed and that the flooding problems will be taken care of with floodwater retarding structures.

E. River Basin Studies

A comprehensive River Basin Study is more intensive than the framework River Basin Studies presently completed in Minnesota. Briefly, a comprehensive survey is an investigation in which the U. S. Department of Agriculture cooperates with a state and other federal agencies under the authority of Section 6 of Public Law 566. The specific objectives of various comprehensive surveys are not identical, but all involve coordination of the USDA programs for water and related land resource conservation development and utilization with similar activities of state and other federal agencies. The intensity of comprehensive studies are aimed at development of plans in sufficient scope and detail to provide a basis for authority of specific federal and federally assisted projects to satisfy the need for resource development during the next 10-15 years. The comprehensive survey consists of six major elements.

(1) Projections of economic development.
(2) Translation of such projections into demands for water and related land resource use.
(3) Appraisals of availability of water supplies, both as to quality and quantity.
(4) Projections of related land resource availability so as to outline the characteristics of projected water and related land resource problems.
(5) A description of the characteristics of present and future problems and a general approach that appears appropriate for their solution.
(6) A detailed feasibility study of specific potential projects within the basin.

2. Economic Research Service

Current investigations concern development and refinement of improved methods for river systems planning, water resource development analysis, economics of water conservation practices, and participation in plan formulation for river basins and subbasins, including investigations to identify and evaluate economic needs for rural areas. Most of the studies are applied economic research. Research at field locations is in cooperation with the Soil Conservation Service, the Forest Service, the Agricultural Research Service and the Minnesota agricultural experiment stations. Cooperative investigations of specific water resource development proposals and problems are also undertaken with state water resource agencies, the Corps of Engineers, the Public Health Service, and other public agencies.

Major elements of ERS participation in the interagency programs include: (a) analysis and projection of (1) economic activity in the agricultural and related sectors of the economy, (2) other economic activity in rural areas, and (3) the demand for land and water resources; (b) assessment of current and projected demands for goods and services obtainable from using water and related land resources and translation of such demands into economic needs for development; (c) analysis of agricultural and rural water problems relating to economic activity in rural areas; (d) economic appraisal of agricultural and rural needs for water and related land resource development; (e) appraisal of prospective economic impact of development alternatives on the agricultural, rural, and related sectors of the economy and the economic relationship of these alternatives to the coordinated and comprehensive development of the study areas.

3. Forest Service

Through Cooperative Federal-State Forestry programs the Forest Service works with state foresters, industries, and other Federal agencies to promote the protection, management and use of state, county, municipal, and privately owned forest resources. Cooperative Forestry also give special emphasis to improving the quality of rural and urban environments. It stimulates research and puts new information from research results into field use. In carrying out these assignments, the Forest Service serves in an advisory capacity on fire control, pest control, flood prevention and river basin planning, and forest management on state and privately owned lands. State forestry agencies also receive assistance with organizational plans.

Assistance in the forestry phases of the Watershed Protection and Flood Prevention Program is carried out in cooperation with state foresters and the Soil Conservation Service. This includes making surveys, preparing plans, and installing land treatment measures on forest lands to reduce storm runoff and sediment production on the watershed projects authorized for planning or approved for operations.

The Forest Service is responsible for detection surveys and biological evaluation on land administered by other Federal agencies such as the Bureau of Indian Affairs and Bureau of Sport Fisheries and Wildlife. This involves technical assistance and advice to managers of Federal forest land for insect and disease control on Federal wildlife areas. The Forest Service also provides similar assistance to state agencies for pest control problems and hydrologic studies involving state and privately owned lands.

Cooperative forest management programs are available to private landowners in the subbasin. The programs are administered through the State Foresters within the subbasin, with the cooperation with the U. S. Forest Service. The programs provide funds for technical assistance furnished in planning and installing forestry practices. The programs include such measures as tree planting, timber stand improvement, harvesting, hydrologic cultural operations, wildlife habitat improvement, and other silvicultural practices. This program can be essential to a landowner if he desires to put his woodland on a productive sustained yield basis.

4. Farmers Home Administration

The Farmers Home Administration has loan authorities which include: (a) watershed loans to local sponsors to finance their share in PL-566 watershed projects; (b) farm ownership loans to enlarge, improve, or buy farms and to refinance debts; (c) soil and water conservation loans to farm families for applying conservation practices; (d) operating loans for making adjustments and improvements in farm and home operations necessary for successful farming; (e) loans to small towns and rural groups to develop domestic water supply and waste disposal systems, and for development of land and water for recreation; and (f) loans to grazing associations for developing seasonal grazing, improving range management, improving soil and water conservation and otherwise shifting land and water resources to better uses including the development of recreational areas and game and wildlife facilities.

5. Extension Service

The Federal Extension Service is part of the cooperative extension partnership. Federal, State and County Governments share in financing, planning and carrying out extension education programs. The Extension Service acts as the education agency of the U. S. Department of Agriculture and the Land Grant Universities. Extension specialist work with many state and federal agencies to provide local people information relating to soil and water management. This work has been an important part of the USDA since 1914 when the Smith-Lever Act created the Extension Service.

6. Agricultural Stabilization and Conservation Service

The ASCS administers several production adjustment programs which have the objective of helping to adjust the production and marketing

of farm crops as a means of stabilizing farm income. Included are: (a) Acreage Allotments and Marketing Quotas, (b) Voluntary Diversion Programs, (c) the Cropland Adjustment Program, (d) the Cropland Conversion Program, (e) the Conservation Reserve of the Soil Bank, and (f) the Sugar Program.

The ASCS also administers the Rural Environmental Assistance Program through which the Federal Government shares the cost of increasing the application of certain soil-building and soil and water conservation practices, including related wildlife conservation practices.

About one-half of the cost of applying these conservation measures is borne by the REAP cost-sharing program. The specific rate of cost-sharing in a county or state is the minimum required to result in an increased performance of the needed conservation practice.

7. Corps of Engineers

In a resolution approved on 10 May 1962 by the Committee on Public Works of the United States House of Representatives, the Corps of Engineers was directed to make a study to determine the advisability of further improvements in the Minnesota River Basin for navigation, flood control, recreation, low-flow augmentation, and other related purposes. Following initial funding of the study late in 1964 and the record breaking floods early in 1965, consideration of available alternative solutions led to the conclusion that a system of major reservoirs on the main stem and principal tributaries of the Minnesota River could provide the most effective solutions to the high and low-flow problems on the Minnesota River.

The system would also alleviate similar problems on the Mississippi River at and below St. Paul. Principal emphasis and priority were given in subsequent study to potential reservoir controls on the Blue Earth River because of the impact of flows of that stream on the Minnesota and Mississippi Rivers. Alternatives considered included a single large reservoir, several small reservoirs, a combination of the large and small reservoirs on the Blue Earth River and local structural and non-structural measures on the Minnesota River from Mankato to the mouth.

Small upstream reservoir sites in sufficient numbers and properly distributed to provide effective runoff control were found to be lacking in the Blue Earth Subbasin. Results of the study on the Blue Earth River indicated that the most effective means of control to provide the greatest downstream benefits for flood control and water quality control would be by means of a single large reservoir about the mouth of the Blue Earth River. A proposal based on this solution presented at public meetings early in 1970 resulted in considerable local opposition and a lack of State support. Consequently the Corps of Engineers deferred further action on the Blue Earth reservoir proposal as well as other units in the

contemplated system pending development by State agencies of a framework plan and policies for management of water resources in Minnesota.

8. Minnesota Department of Economic Development

   The Minnesota Department of Economic Development is taking an active interest in the study as the state agency responsible for overall economic base studies. The Department has considerable primary data describing the manufacturing activity and community economic statistics for the subbasin.

9. Department of Natural Resources

   The Minnesota Department of Natural Resources manages much of the states natural resource and recreation program. The following is a brief listing of the programs carried out by each of the department divisions.

   A. Division of Lands and Forestry

      Management assistance to private owners of forest land.

   B. Division of Enforcement and Field Service

      Acquire, develop and maintain public access sites on lakes and rivers.

   C. Division of Parks and Recreation

      Acquire, develop and maintain state parks, recreation areas and trail systems. Developments near the subbasin area include Minneopa State Park and Sakota Singing Hills Trail which will run from the Benning Junction in Blue Earth County in a northeasterly direction approximately 42 miles to Faribault Junction in Rice County on railroad right of way.

   D. Division of Waters, Soils and Minerals

      (1) Shoreland and Floodplain management
      (2) Lake classification
      (3) Hydrologic data collection

   E. Division of Fish and Game

      (1) Upland Game research (Madelia Research Station)
      (2) "Operation Pheasant" (10-year experimental program)
      (3) Wetlands acquisition and development
      (4) Game Lake surveys
      (5) Game censuses
      (6) Wildlife management on private and public lands
      (7) Fisheries research (Waterville Headquarters)

(8) Fish lake and stream surveys
(9) Acquisition, development and management of northern pike spawning areas
(10) Operation and maintenance of walleye rearing ponds
(11) Stock of game fish
(12) Rough fish control
(13) Lake rehabilitation for sport fishes or waterfowl with fish toxicants
(14) Fish management in public waters
(15) Aquatic nuisance control
(16) Pollution investigations related to fish and wildlife kills
(17) Lake sounding and mapping
(18) Special studies and investigations concerning the effects of proposed water and related land resource projects on fish and wildlife resources

VII. WATER AND RELATED LAND RESOURCE DEVELOPMENT POTENTIAL

1. Impoundments

A. Upstream Reservoir Potential for Any Purpose

An inventory was made of potential upstream reservoir sites to determine the physical potential of storing water for any purpose within the Blue Earth River Subbasin. The results of this study are shown in Appendix 1, including site maps, storage curves and preliminary structure data.

Appropriate Task Committees designated by the Southern Minnesota Rivers Basin Commission should review the potential sites and determine their value for recreation, fish and wildlife, municipal water supply, low flow augmentation, irrigation, and flood prevention. County Commissioners, Soil and Water Conservation District Supervisors, and other interested groups could also aid in identifying purposes and local interest for developing these sites.

Of the 119 sites studied, 76 were found to have adequate storage for flood prevention. Any of these sites could be used to reduce flooding in upstream areas, especially during the more frequent floods which are most significant to agricultural lands.

The sites are not all located to the best advantage in relation to areas subject to flooding. To be most effective for flood prevention, reservoirs should control a high percentage of the watershed area above floodplain areas to be protected. The topography in the basin very frequently does not offer adequate storage capacity at such locations. The sites were located wherever storage possibilities were found and some may be more useful for purposes other than flood control.

Storage in addition to that normally required for flood prevention is available in 44 of the sites. Multipurpose reservoirs could be developed at these sites for any desired beneficial use, such as recreation, fish and wildlife, irrigation or possibly water supply. The suitability of individual sites for any specific additional purpose has not been determined. Several levels of development of these sites are shown in Appendix 1.

It is possible to make use of the above sites as single purpose reservoirs without considering flood prevention. Some of the sites which were found to be inadequate for flood prevention might be useful for other purposes. These sites are also listed in Appendix 1, but were not investigated beyond available storage estimates.

B. Upstream Reservoir Potential for Control of Downstream Flooding

Upstream reservoirs and additional storage on existing lakes will not provide significant reduction in flooding on the mainstem of the Blue Earth River or the Minnesota River. A study of 119 potential reservoir sites and 168 existing lakes showed that they could reduce the peak flood flow for the 1965 flood no more than about 15 percent at the mouth of the Blue Earth River and about 10 percent on the Minnesota River at Mankato. Therefore, developing upstream storage in the Blue Earth Subbasin to reduce mainstem flooding on the Blue Earth River and Minnesota River is not feasible. Nor is there an adequate amount of upstream storage in the relatively flat Blue Earth River Subbasin to feasibly reduce the floodwater storage design of the Blue Earth Dam contemplated by the Corps of Engineers.

The Soil Conservation Service made a specific study of 65 potential upstream reservoir sites that together would provide a compatable system to compare as an alternative to the large dam on the Blue Earth River near Mankato. These sites were compared to the large dam (1) in physical terms such as in volume of storage, drainage area controlled and land required and (2) in terms of hydrologic effects downstream by the use of a hydrologic mathmatical computer model.

In physical terms the 65 upstream reservoirs would provide only about 10% of the storage provided in the large dam, control just 25% of the drainage area, and inundate over twice as much good Class I and II cropland in the reservoir pool area.

The hydrologic model indicated that the upstream reservoirs would have reduced the 1965 flood peak at the mouth of the Blue Earth River by about 12%. The large dam could have been regulated to reduce the 1965 peak flow by 99% if necessary to control flooding on the Minnesota River.

It is not possible to predict the effect that the upstream reservoirs would have on future floods on the Minnesota River. It is estimated that the upstream reservoirs could reduce peak flows on the Minnesota River at Mankato by as much as 10 percent, however, due to the timing of the peak flow on the Blue Earth River and the Minnesota River, upstream reservoirs could also increase the peak flow on the Minnesota River.

The cost of the potential upstream reservoirs is estimated at about $20 million compared to about $145 million for the proposed large dam. It might be proven justifiable to spend $20 million for the 65 upstream reservoirs if enough upstream

benefits were found. Even so, the large dam would still be needed at essentially its present design to accomplish the purpose of mainstem flood prevention.

Questions still remain as to the expected economic impact of the large dam. These questions need to be resolved by the Economic Base Task Committee before the SMRB Commission can make a determination on whether to include the large Blue Earth Dam in the River Basin plan.

Some readers of this report might wonder why SCS became involved in locating upstream reservoir sites and evaluating their effect on flooding so far downstream. Others may be interested in how we made our study and would like more detail than we have presented so far. We hope the following paragraphs will adequately satisfy such interest.

Water resource planning, if it is to be productive, must involve the citizenry in the initial stages of the planning process, bring the conflicts out into the open, and then try to resolve them. One such conflict, in the minds of many of the people in the Blue Earth Subbasin, is the conflict between upstream and downstream reservoirs for flood protection.

The conflict arose in this subbasin when the Corps of Engineers proposed a large dam near the mouth of the Blue Earth River. The proposed structure would provide flood protection primarily along the Minnesota River downstream from the mouth of the Blue Earth River and on the Mississippi River downstream from the mouth of the Minnesota River.

Although the Corps studied several alternatives including several small reservoirs and a combination of large and small reservoirs they found that the most effective means of control to provide the greatest downstream benefits for flood control would be by means of a single large reservoir above the mouth of the Blue Earth River. When this proposal was presented at public meetings it received considerable local opposition and a lack of State support. Opposition arose primarily from rural landowners and from the residents of Garden City who were located in the proposed reservoir area.

Others in the Blue Earth Subbasin were opposed to the large dam because they felt that too much land would be taken off the tax rolls in one area, that too many roads would be closed and that drainage would be destroyed on thousands of acres of cropland surrounding the reservoir. The general sentiment of the local people was that they should not have to give up their land to protect someone elses land and property downstream.

With the exception of recreation benefits, the proposed large dam served primarily the downstream interests. Upstream interests felt that if any plan was to be formulated it must include benefits to upstream landowners as well or at least not be detrimental to the upstream landowners.

Local interested groups, such as the Blue Earth Policy Committee, speculated on possible alternatives to the proposed large dam that would not be objectionable to the upstream interests. Speculation centered on the possibility of storing water in small upstream impoundments. In considering this possibility, three basic assumptions were made:

(1) Major floods that concern the downstream interests occur from spring snowmelt runoff.
(2) Spring snowmelt runoff can be stored in small upstream impoundments without being detrimental to upstream interests.
(3) Enough small upstream impoundments could be installed to reduce downstream flooding to the point where the proposed large dam would not be needed or could be greatly reduced in size.

Several types of upstream impoundments were suggested, the following being the most common:

(1) Floodwater retarding structures such as those being constructed in the Soil Conservation Service Small Watershed Program.
(2) Farm pond type structures such as those being constructed by SCD Cooperators with SCS technical assistance.
(3) Use of low head dams to store water on existing lakes and in lake basins that have been drained.
(4) Storage above roads by the use of mechanical gates on culverts or modification of existing culvert size.

As stated earlier, water resource planning must involve the citizenry. If the citizens are to accept a plan, all reasonable alternatives must be studied to the satisfaction of the people. The following paragraphs are an attempt to show the effect that small upstream reservoirs have in general and the effect that upstream reservoirs would have in the Blue Earth Subbasin and downstream on the Minnesota River.

The effect of small upstream reservoirs on downstream main stem flooding is often misunderstood. Much of this misunderstanding has arisen due to the failure of hydrologists to fully explain the effectiveness of upstream reservoirs

on main stem flooding. The often heard statement, "hold the raindrop where it falls", can only apply to a certain amount of rain and to certain physical areas.

Small upstream reservoirs are most effective in controlling floods on upstream tributaries caused by storms covering a small area. The effects diminish in magnitude downstream as the drainage area increases. Thus small upstream dams seldom can be substituted for dams on major rivers if the purpose is to control main stem flooding. Main stem dams obviously have no effects on flooding in upstream tributaries. Therefore, upstream dams and main stem dams usually provide benefits to areas that are geographically separate.

Many studies have been made on the effects of small upstream reservoirs on main stem river flooding, both in specific river basins using actual physical data, and in hypothetical river basins using the fundamental principles of hydrology and hydraulics which apply to all drainage basins.

One such study was made in the Meramec River Basin in Missouri by A. W. Zingg in 1946.[1/] In the Meramec basin with a drainage area of 3,939 square miles, Zinggs' upstream reservoir system consisted of 198 dams, or one dam for every 20 square miles drainage area. Zingg placed the reservoirs on the basin map and found that the dams controlled 51 percent of the drainage area. He assumed the dams could store 2 to 3 watershed inches of water and had release rates of 10 cubic feet per second per square mile. Zingg found that small reservoirs, as an average, produce a flood reduction of approximately 35 percent on headwater tributaries which drain areas of from 50 to 125 square miles. The reduction became progressively less in the downstream direction and reduced to approximately 20 percent on the main stem of the Meramec River.

Other studies support Zinggs conclusions. In river basins which have normal drainage density it is generally possible to control approximately 50 percent of the drainage area by small reservoirs on the upstream tributaries. With this amount of control it is possible to reduce the peak flood discharge on the main stem approximately 20 to 35 percent depending on the type of storm that occurs and the size of the drainage basin.

1/ A Study of Small Upstream Reservoirs in the Meramec Basin, Missouri Dept. of Resources and Development, Jefferson City, Mo., Processed. 69 pp.

Several other general reasons can be given why upstream reservoirs are not usually feasible for control of main stem flooding. Small upstream reservoirs, although distributed throughout a basin, require more land acquisition for the same amount of flood storage than one large reservoir. The area inundated by a reservoir is equal to the volume of water stored divided by the average depth. Obviously the smaller the reservoir the smaller the average depth. Thus, if the same amount of water is to be stored, more land will be inundated by shallow reservoirs than deep ones. Using this same principal it can be shown that the cost of storing water per unit volume increases rapidly as the size of a reservoir decreases.

In summary, it can be concluded that generally small upstream reservoirs are not usually an alternative to large main stem reservoirs if the purpose is to control main stem flooding although they often supplement the large reservoirs to provide a good water management program for the watershed area.

Specific studies of upstream reservoirs in the Blue Earth Subbasin and their effect on flood flows in the downstream areas supports these conclusions. The Soil Conservation Service made an inventory of the potential upstream reservoir sites in the subbasin. Of the 119 sites studied, 76 were found to have sufficient storage for flood control purposes. Further studies showed that 65 of these 76 sites would be compatible in a reservoir system. A complete description of how the inventory was conducted and other detailed information about the reservoir sites can be found in Appendix 1.

A hydrologic mathematical model was prepared which allows simulation of the 1965 flood on the Watonwan and Blue Earth Rivers downstream to the stream gage near Rapidan. The purpose of the model was to evaluate the effect the upstream reservoirs would have had if they had been installed prior to the 1965 flood.

Of the 65 potential reservoirs 44 are located in the Blue Earth and Watonwan River watersheds. These 44 reservoirs would control 657 square miles of the total watershed area of 2339 square miles. The area that would be controlled would be 27 percent.

The 44 reservoirs were placed in the watershed model and the 1965 flood was routed. The results show that the 1965 flood discharge would have been reduced by 12 percent at the stream gage near Rapidan. It is assumed that the 21 potential reservoirs in the Le Sueur River watershed would

also reduce the 1965 flood discharge such that the reduction for the entire subbasin would be approximately 12 percent.

The 65 potential floodwater retarding reservoirs in the entire subbasin would control 870 square miles of the total of 3476 square miles. This amounts to a controlled area of 25 percent. Due to the low natural drainage density in the subbasin, the possibility of controlling 25 percent of the drainage area with small upstream reservoirs is a realistic figure as compared to the 50 percent figure for basins with average drainage density. The 12 percent reduction in peak discharge with 25 percent control also compares favorably with the average of 20 to 35 percent reduction with 50 percent control.

Due to the variation in timing of peak flows, the effect that upstream reservoirs in the Blue Earth Subbasin would have on future floods on the Minnesota River cannot be predicted with any degree of confidence. Our studies of the 1965 and 1969 floods point out this fact.

It is estimated that the upstream reservoirs would have reduced the 1965 flood peak flow on the Minnesota River at Mankato by about 9 percent. This reduction is considered to be near the maximum that could be expected from the upstream reservoirs considering the timing of the high flows on the Blue Earth River and the Minnesota River. In many floods, the upstream reservoirs could delay the flood peak on the Blue Earth River which could cause a higher flow on the Minnesota River.

Studies of the 1969 flood are an example of this. The upstream reservoirs would have reduced the 1969 peak flow on the Blue Earth River by four percent and delayed the peak by one day. The one day delay of the peak flow on the Blue Earth River (although reduced) would have caused a four percent increase in the peak flow on the Minnesota River at Mankato.

The dam studied by the Corps of Engineers is designed to allow regulation of the outflow from the reservoir so that a maximum reduction in flow could be obtained on the Minnesota and Mississippi Rivers.

The 65 upstream reservoirs would require 27,320 acres of land with a design storage capacity of 155,900 acre feet. The dam proposed by the Corps of Engineers would require 25,700 acres of land with a design storage capacity of 1,225,000 acre feet. A comparison of total cost, cost per acre foot of storage and the amount of land required per acre foot of storage for the upstream reservoirs and the

large reservoir proposed by the Corps of Engineers can be found in Figure 7.1. The types of land that would be affected by the upstream reservoirs and the proposed Corps of Engineers reservoir is shown in Table 7.1.

One of the assumptions made by many people is that the small reservoirs would be designed to store only the water from the spring snowmelt and that the inundation of land would not be detrimental during this time of the year. This assumption is not realistic for several reasons. Research has shown that reduced crop yields may be expected for each day planting is delayed beyond a certain optimum date. It is obvious that in some years the inundation of cropland above reservoirs will delay seeding and be detrimental to crop yields.

Structures that would store water only during certain periods of the year would require an integrated system of reservoir regulation. Even if an efficient system of reservoir regulation could be established it would undoubtedly be subject to a great deal of controversy between upstream and downstream interests in any given year. Obviously time will be required to release the snowmelt runoff which is stored in the upstream reservoirs. The date that drawdown should begin in order that inundation will not cause delayed seeding will also be affected by rainfall during the drawdown period which of course cannot be predicted. Conflicts between upstream and downstream interests within the Blue Earth Subbasin itself would undoubtedly arise.

A regulated spillway that would allow storage of spring runoff but would pass the runoff from a summer rain without damage upstream would be much more expensive to construct than the unregulated spillways normally used for small reservoirs.

The possibility of storing spring snowmelt runoff in existing lakes and lake basins that have been drained was also suggested. Storing snowmelt runoff in lake basins, <u>which have been drained</u>, for the purpose of providing main stem flood protection is generally not feasible for the same reasons listed for small upstream reservoirs. Storing spring snowmelt runoff <u>in existing lakes</u> appears to be more feasible from the standpoint of being less detrimental to cropland.

Some of the 119 reservoirs which were studied in the reservoir site inventory were located on existing lakes or drained lake basins. Specific studies were not made of the possibility of storing water on <u>all</u> of the existing lakes. Obviously it is not feasible to store water on many of the existing lakes due to the development surrounding lakes and the limits of the topography.

FIGURE 7.1

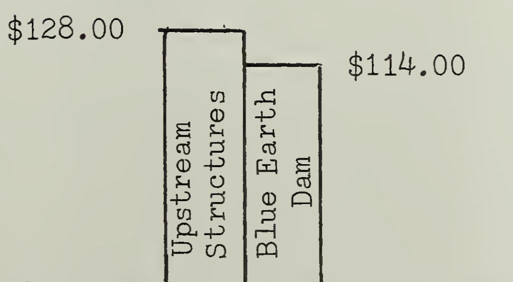
Comparison of Corps of Engineers
Proposed Blue Earth Dam and 65 Upstream Sites,
Blue Earth River Subbasin

	Upstream Sites	Blue Earth Dam
No.	65	1 2/
Storage (Ac. Ft.)	155,900	1,225,000
Percent of Drainage Area Controlled (Blue Earth River Subbasin)	25	100
Land Required (Acres)	27,320	25,700
Cost	$20,010,000 1/	$139,484,000

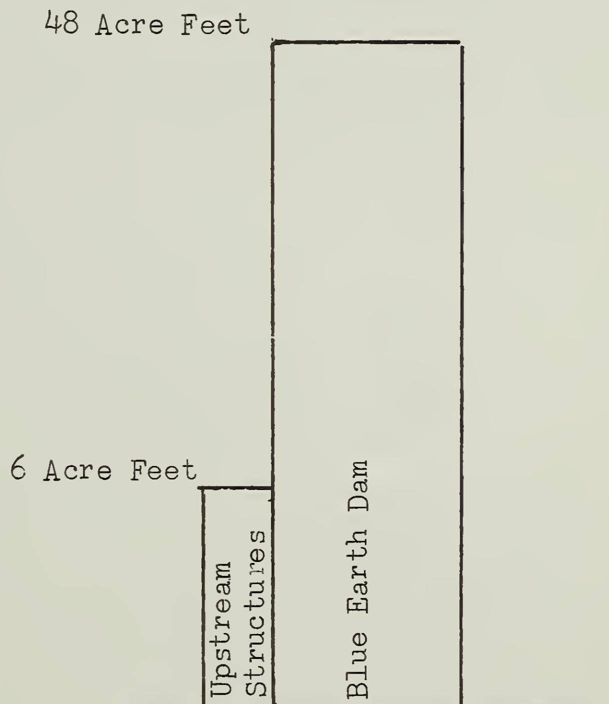
1/ Does not include "Land Rights" cost other than acres required at top of dam elevations

2/ As presented 19 February 1970

Graph Comparison:



Cost per acre foot storage



Acre feet of storage per acre of land required

TABLE 7.1

Comparison of Corps of Engineers Proposed Blue Earth Dam and 65 Upstream Sites, Blue Earth River Subbasin

Land Requirements

Land capability classification by acres for the land which would be included in the maximum pool area of (1) the proposed U. S. Corps of Engineers Blue Earth River Reservoir (2) 65 potential small upstream reservoirs.

Land Capability Class	65 Upstream Reservoirs (Acres)	C of E Blue Earth River Reservoir (Acres)
I	9,856	2,313
II	9,364	5,654
III	4,928	6,168
IV	246	386
V	0	0
VI	246	2,827
VII		8,224
VIII		128
Existing Lakes	2,680	
Total	27,320	25,700

For the purpose of this report a lake is defined as a natural enclosed depression, 10 acres or more in area which has substantial banks capable of containing water and which are discernable on aerial photographs. There are 468 lakes of this description in the Blue Earth Subbasin. One-hundred and sixty-eight of these lakes have not been affected by drainage. The drainage area above the 168 lake basins has not been determined so the percent of drainage area controlled by existing lakes is not known. The available storage capacity likewise has not been determined, however some estimates of storage can be made from the known surface area. For the purpose of speculation on the potential of controlling downstream flooding by storing water on existing lakes the following assumptions are made:

(1) All existing lakes are located such that they are capable of storing 3 inches of runoff from the contributing watershed.
(2) All existing lakes can be raised an additional 5 feet during periods of snowmelt runoff.
(3) All existing lakes have a vertical shoreline.

The surface area of the 168 existing lakes that have not been affected by drainage is about 32,200 acres. Under the assumptions made above, these lakes could store 161,000 acre feet of water if they were raised 5 feet. If the lakes were capable of storing 3 inches of water the drainage area controlled would be 1007 square miles or 29 percent of the total subbasin. The assumed 29 percent area controlled by lakes, which is a drainage area to lake area ratio of 20 to 1, assumes somewhat ideal conditions. Actually most of the lakes do not have this large a drainage area to lake area ratio.

The assumed potential of controlling 29 percent of the drainage area and storing 161,000 acre feet of floodwater in existing lakes is comparable to the 25 percent area controlled and the 155,900 acre feet of storage possible with a system of small upstream reservoirs. With this amount of control the most reduction in main stem peak discharge (from a flood such as occurred in 1965) that could be expected would be 12 to 15 percent.

Thus assuming all of the lakes were in an ideal location to control floodwater and that they could all store a significant amount of floodwater, the discharge on the main stem still wouldn't be reduced a significant amount.

Storing spring snowmelt runoff above most of the roads in the subbasin would appear to provide a great deal of control, but this alternative is also not realistic for several reasons. Some of these reasons include:

(1) Road fills, if not reconstructed as dams, would fail or require a very high degree of maintenance if water were stored for prolonged periods.
(2) All culverts and bridges would have to be redesigned in order to provide some degree of flood protection and still allow passage of a certain frequency of flood without overtopping the road. It is not practical to assume that floodwater can be stored above roads by placing restrictions on existing culverts.
(3) The system would require regulated spillways if the land upstream were not to be inundated from summer floods. The control of snowmelt floods would require such a complex system of reservoir regulation that it would be impractical if not impossible to manage.

Storing water above roads requires the same consideration as storing water in small reservoirs except that usually road structures are designed with a higher degree of safety.

In summary, small upstream impoundments have a purpose as do large main stem impoundments. They each provide certain benefits to certain areas. A system of upstream impoundments cannot generally replace protective works downstream, nor is the reverse true.

C. Effects of Reservoirs on Drainage Systems

The adverse effects of either upstream or downstream reservoirs on existing drainage systems depends largely on the topography surrounding the reservoir site. A well entrenched site having steep valley walls and a relatively steep stream gradient will affect drainage on a smaller area of adjacent land than a site located in a flat area surrounded by low lying land.

The proposed reservoir site at the mouth of the Blue Earth River is favorable from this standpoint except for short reaches along tributary streams. Preliminary study would indicate no adverse effects to drainage outlets above the maximum flood pool elevation of 966 feet above mean sea level. The proposed large reservoir would however, inundate all drainage outlets below the planned conservation pool elevation of 852. The frequency of inundation of drainage outlets between elevation 852 and elevation 966 would vary

according to the amount of storage required to control an individual flood event. Thus drainage outlets near elevation 852 would be inundated frequently and outlets near elevation 966 would be inundated very infrequently.

Many of the 65 upstream reservoir sites that were studied are located in areas that contain sloughs and lakes. These are frequently areas with drainage problems aggravated by low outlet gradients above the potential reservoir areas. Although no specific studies were made, it is estimated that the 65 upstream reservoirs would cause impaired drainage on more adjacent land than would the proposed large reservoir. Detailed studies must be made of an individual reservoir to determine its effect on surrounding drainage systems.

2. Ground Water Development

Most of the Blue Earth Subbasin is in an area of ground water recharge and no areas of significant ground water decline are known. There appears to be an almost unlimited potential for further development. Because ground water availability varies locally, detailed investigations are necessary in some areas to guide resource development, especially where large ground water supplies are needed.

3. Channel Improvement and Levees

Channel improvement is typically used in agricultural areas as a method of protecting cropland from frequent flooding during the growing season. Channel improvements that have been planned in recent years for the protection of field crops have been designed to confine a two to five year frequency flood within the banks of the channel. Channel improvement costs generally begin to reach a point of diminishing return when channels in agricultural areas are designed to control a flood greater than the five year frequency.

Considering the Blue Earth Subbasin as a whole, the need for channel improvement for flood control purposes is not great. Frequent flooding during the growing season does not occur on a great extent of the land in the subbasin.

Adverse affects on wildlife habitat, impact upon scenic beauty, channel stability problems, induced downstream damages if adequate outlets are not obtained and other related characteristics are factors which place limits on the potential for channel improvement.

4. Irrigation

There are approximately 30,000 acres of land in the Blue Earth Subbasin with soils that have a potential for irrigation. Figure 5.4 outlines very generally those areas with a significant proportion of droughty soils. Included in this group of soils are Dickinson, Dickman, Esterville, Grogan, Litchfield, Rosendale, Salida and Sparta series. These soils range from medium to low moisture holding capacity. The relief associated with these soils is nearly level to gently rolling with a few short steep slopes.

Figure 5.4 can serve only to identify general areas where the majority of soils would respond to irrigation. Detailed evaluation of a specific area would be necessary to determine feasibility. Factors which complicate any general statement about the desirability of irrigation in these areas include:

(1) Moderately droughty and droughty soils are associated or intermingled.
(2) Poorly drained soils intermingle with moderately droughty and droughty soils.
(3) Medium acid to neutral, moderately droughty soils are intermingled with neutral to highly calcareous, poorly drained soils.
(4) Thin, finer textured strata in the underlying material may modify moisture storage and water transmission characteristics.
(5) Sandy soils may unevenly mantle medium textured glacial till. This condition modifies estimated droughtiness.
(6) Within each area outlined are significant areas of non-droughty soils, but the areas are too small to be delineated on a map of this scale.

Water supplies for irrigation are generally available from ground water sources and in limited instances from surface water supplies. Here again, evaluation of a particular site would be necessary to insure that a sufficient water supply of acceptable quality was available. A permit for the appropriation of ground and surface water must be obtained from the Minnesota Department of Natural Resources before water can be used for irrigation.

Modern irrigation systems are extremely expensive and can involve many additional hours of labor to operate. Therefore, strict analysis of the cost and benefits anticipated is required before any decision to begin such an operation is made. The following summary is intended for information purposes to help recognize basic cost-return considerations.

In this example it is assumed that the required physical setting, equipment costs and operating costs (including increased labor, machinery and other input costs) have been analyzed. Costs have been converted to an average annual basis to make them comparable with annual returns.

Irrigation Cost Analysis Summary - 120 Acres

(1)	Annual ownership costs	\$ 1,363.04
(2)	Annual operating costs	\$ 530.73
(3)	Total annual irrigation costs (1+2)	\$ 1,893.77

Comparing Dryland vs. Irrigation:

(4)	Expected gross value of crops from dryland farming. 120 (acres) x 100 (yield/acre) x \$1.00 (price/unit)	\$12,000.00
(5)	Gross value of crops needed to make irrigation at least as profitable as dryland (3+4)	\$13,893.77
(6)	Total irrigated crop production needed to break even with dryland crop production (5 ÷ price/unit)	13,894 bu.
(7)	Yield per acre needed to break even (6 ÷ acres irrigated)	115.8 bu.
(8)	Your estimated average yield per acre under irrigation	140 bu.
(9)	Your estimated added income per acre due to irrigation (8 - 7) x (price/unit)	\$ 24.20
(10)	Your estimated total added income due to irrigation (9 x acres irrigated)	\$ 2,904.00

The future use of ground and surface waters for irrigation will depend mainly on the prospects for increased crop yields and expected price levels. Unless annual benefits obtained sufficiently exceed the annual costs of the irrigation system, the investment would not be worthwhile. A large number of the subbasin farmers do not raise high value commercial crops and probably will not do so in the future; consequently, the value of irrigating lower value crops will depend upon intensive evaluation to insure profitability.

5. Recreational Developments

The purpose of this effort is to propose a land use policy for lands desirable as environmental corridors. The proposal is directed to local governments for their consideration in preparing local floodplain and shoreland ordinances and policies.

By definition, environmental corridors generally encompass the best remaining elements of the natural resource base. These include lakes and streams, their associated shorelands and floodplains, wetlands, woodlands, wildlife habitat areas, areas containing rough topography and significant geologic formations and the best remaining sites for park and "open space" uses.

Two general types of corridors are proposed, recreational and wildlife habitat. Both are water based. Emphasis is placed on recreational corridors as they can provide multiple benefits to water, wildlife, recreation and forestry.

Recreational corridors are subdivided into three categories: "mobile", "local", and "wild and scenic". Mobile corridors are primarily a system of land and water trails, while local corridors are of a park design. Wild and scenic corridors will essentially preserve and maintain areas in an undeveloped state.

Wildlife habitat corridors are less involved and do not require public ownership. These areas are designated for wildlife and fishery enhancement, and will remain in private ownership for the control of public use. Where desirable, State acquisition is feasible to provide a optimum combination of public and private ownership.

The minimum requirements for recreational corridors are continuous or intermittent natural vegetation, continuous streamflow during the summer and fall months, adequate available acreage, and desirable level of accessibility.

To determine the priority for establishing environmental corridors, we recommend the criteria set forth by the state funded Project 80 -- A Study of the Total Environment with minor modifications. Primary and secondary criteria are used to screen and evaluate potential sites. Primary criteria set the minimum standards and are based on uniqueness, significance, utility and need. Secondary criteria rank the qualifying sites on the basis of distance from population centers, qualities, level of importance, endangered status, size, availability to people, variety and topography.

An important characteristic of environmental corridors is their ability to provide multiple and compatible benefits. Environmental corridors can provide a form of floodplain management for flood damage reduction, streambank erosion control, sediment reduction, and nutrient pollution abatement.

Corridors provide wildlife benefits in the form of varied wildlife habitat and winter cover. Good forestry practices insure a desirable level of tree stocking, species composition

and forest health and vigor. Through insect and disease control, harvesting, and timber stand improvement, the growth and productivity of these sites can be sustained. Recreational values will be enhanced by the development of recreational facilities and the resource management provided to obtain watershed, wildlife and forestry benefits. Certain residential uses are compatible with the environmental corridor setting. Such developments would have to be well planned, follow specially designed specifications and be adequately maintained.

With the above definition and objectives in mind, a potential exists in the following areas for corridor use. Recreational corridors are applicable to the Blue Earth River Valley, the LeSueur River Valley, the Watonwan River Valley, the extreme lower valley segments of the East Fork of the Blue Earth River, Elm Creek and Maple River, the Fairmont chain of lakes and all other lake sites that may qualify. To facilitate public access, recreational local corridors are most advantageous at the junction of major highways and these valley and lake sites. Wildlife habitat corridors are proposed on the remaining floodlands, woodlands and lake sites that do not qualify as recreational corridors (see Figure 7.2). These areas in total or in segments would qualify under the existing criteria. The environmental corridor criteria of: need, multiple utility, uniqueness, endangered status, significance and variety are self evident and easily identified in the Blue Earth River Subbasin.

Should environmental corridors be established, substantial social and economic gains would be realized. As corridors can provide a multitude of uses, an economic gain to the local community is assured.

A few of the <u>advantages</u> can be:

(1) Environmental corridors are a natural locale that can help meet the increasing demand for outdoor recreational opportunities. Therefore, increased revenues to adjacent local economies can occur in both direct and indirect goods and services.

(2) Environmental corridors can be a means to achieve floodplain zoning, thereby reduce flood damages and costs to local, state and federal taxpayers.

(3) Environmental corridors can preserve the integrity and productivity of this natural resource for both social and economic utilization.

(4) Corridors presently serve as the last remaining large tracts of winter wildlife cover. Under proper management,

the enhancement of both game and non-game species can be achieved, and thereby increase the social and economic values of this resource.

(5) Environmental corridors can provide areas for environmental research and education.

(6) Environmental corridors inhibit the use of these productive river valleys for a single purpose use such as residential developments.

A few of the disadvantages of environmental corridors are as follows:

(1) Corridor implementation will rely heavily on local governments which are limited in both staff and funds.
(2) Restriction of the industrial, commercial, urban and residential expansion into prime natural areas will result in the loss of economic and tax gains from such expansion.
(3) Corridors and zoning will affect a large number of people due to land use restrictions and, possibly, condemnation proceedings.
(4) Local corridors will reduce regional flood damages only if similar programs are established downstream.

Some government measures that encourage the establishment of the environmental corridors are the State of Minnesota standards for shoreline and floodplain zoning, the federal Housing and Urban Development floodplain insurance program and existing county zoning ordinances.

Lands designated for mobile and wild and scenic recreational use could, in the beginning, be obtained through use easements and land rentals. As public use increases, outright acquisition of these lands may be necessary. Lands for local recreational corridors should be acquired due to the intensive and extensive public use. Land acquisition should be made at the earliest possible time as land value will become prohibitive in the future. Whenever desirable, corridors could be established and maintained under the use easement system.

Funding for environmental corridors' land acquisition, will rely heavily on local and county governments. Federal and State funds for land acquisition and development are readily available under the various Minnesota Department of Natural Resources' programs and "Lawcon" funds administered through the State Planning Agency. Financial responsibility for maintenance of the areas would rely on local governments. Many forestry and wildlife measures could be prescribed by the state agency responsible for these services. In addition to State and local funds, federal funds for outdoor recreational assistance are available under various programs administered by the Department of Defense, Department of

Note: Basin boundary is being revised

POTENTIAL ENVIRONMENTAL CORRIDORS

Study Area 1 - BLUE EARTH RIVER SUBBASIN

of the

MINNESOTA RIVER BASIN

portion of the

SOUTHERN MINNESOTA RIVERS BASIN STUDY

MINNESOTA, SOUTH DAKOTA, AND IOWA

SCALE 1/500,000 SCALE 5 0 5 10 15 MILES SCALE 1/250,000

TRANSVERSE MERCATOR PROJECTION

SOURCE:
AMS 1/250,000 TOPOGRAPHIC MAPS, MINNESOTA AND IOWA COUNTY HIGHWAY MAPS AND INFORMATION FROM THE FIELD TECHNICIANS.

Fig. 7.2 5,S-29226

Health, Education and Welfare, Department of Housing and Urban Development, and the Department of Labor. Specific programs will be discussed in detail in the final report.

For the present, a survey of the land ownership, values, and uses are of the utmost importance. It is suggested that an education and information program be installed during the planning stage to present the environmental corridor concept to state and federal governments, and the landowners. This program can help determine local attitudes and potential problems. The information and educational programs should include alternatives for land acquisition, liability laws, and the proposed environmental corridor regulations.

In summary, there is a physical and economic potential to develop environmental corridors in the Blue Earth River Subbasin. This project would provide multiple benefits of watershed protection, recreation, forest products, wildlife, and rural development. Furthermore, this policy would inhibit the loss of this valuable natural resource to a single purpose use.

We hope this approach will be useful to the sponsors and help promote optimum land use in their respective counties.

6. Fish and Wildlife Developments*

7. Water Quality Control*

*Investigations are being made by the Soil Conservation Service. Studies need to be coordinated with state and federal agencies.

8. Flood Plain Management

A. Floodplain Management Regulations and Considerations

Non-structural means of reducing or preventing flood losses should be considered as an important alternative in meeting a flood damage reduction objective. In 1969 the Minnesota Legislature enacted the Flood Plain Management Act. Under the law, state regulations along with locally adopted ordinances would provide guides for maximum allowable development of flood hazard areas. Regulations must be developed for all watercourses with a drainage area of 2 square miles or greater.

Local governments are responsible for:

(1) Submitting to the Department of Natural Resources data on local flood hazards.
(2) Adopting a floodplain management ordinance when sufficient technical information is gathered.
(3) Administering and enforcing the ordinance once it is enacted.

Floodplain management is necessary to bring an optimum land use into existence. Rural and urban floodplains are prime areas for future municipal, industrial, commercial and agricultural expansion. Associated with this expansion is an increasing potential for flood damages. One of the alternatives in controlling flood damage is floodplain management and zoning. Floodplain management is essentially non-structural and has these advantages and disadvantages when compared to structural measures.

Disadvantages:

(1) Structural measures are relatively localized, having a direct impact on a relatively small number of people. Non-structural measures have a wide-spread nature and impact through needs of individual participation and cooperation, property use restrictions and mandatory property sale.[1/]
(2) Structural programs are usually designed, planned, financed and built by government agencies having specialized staff. Implementation of non-structural measures usually falls on small units of government whose limited staff and funding must deal with the entire spectrum of public administration.[1/]

1/New York State Water Resources Commission, Erie Niagara Basin, Approval for Flood Plain Management, Conservation Dept., Div. of Water Resources, New York, PL Memo No. 3, 1968

(3) Federal, state, regional planning organizations have rejected this non-structural measure as it only provides local flood damage reduction and is not effective to downstream regions unless a similar program is in effect there too.2/

Advantages:

(1) Costs are usually born directly by the beneficiaries.1/
(2) Cash outlays are small and can be staged over a long period of time.1/
(3) Non-structural measures are more permanent, and have a longer life than structural measures.1/
(4) Floodplain management and zoning limits the future encroachment and decreases flood damages in the floodplain. Furthermore, it encourages existing developments to install flood proofing and flood insurance measures.2/
(5) Non-structural measures encourage downstream regions to install similar programs, thereby creating a uniform system throughout the basins.2/

B. Floodplain Management Studies in the Subbasin

The Minnesota Flood Plain Management Act requires that regulatory controls be placed on areas that would be inundated upon occurrence of a 100 year frequency flood. Encroachment is generally allowed within the 100 year frequency flood area provided the encroachment does not raise the 100 year frequency water surface more than 0.5 foot. Thus the allowable extent of floodplain development depends upon the degree of encroachment introduced and the effect of the encroachment upon the 100 year frequency flood profile.

In the determination of the 100 year frequency flooded area, the 100 year frequency flood elevations and the evaluation of the effects of floodplain encroachment, it is usually necessary to rely on detailed engineering studies. The Soil Conservation Service made detailed engineering studies of the area flooded by the 100 year frequency flood in portions of Blue Earth County. These studies were performed in cooperation with Housing and Urban Development under the National Flood Insurance Program.

1/New York State Water Resources Commission, Erie Niagara Basin, Approval for Flood Plain Management, Conservation Dept., Div. of Water Resources, New York, PL Memo No. 3, 1968

2/Water Resources Coordinating Committee, Alternate Programs and Projects for Managing Minnesotas' Water and Related Land Resources through the Year 2020, State Planning Agency, St. Paul, Minn. 1971

The area flooded by the 100 year frequency flood in the portions of the Blue Earth County that were studied, and are in the Blue Earth Subbasin, are shown in Figures 7.3, 7.4, 7.5, 7.6, and 7.7. More detailed information may be obtained from the Soil Conservation Service.

9. Land Use Planning

Floodplain management is but a segment of overall land use planning. Zoning regulations by communities and counties in the Blue Earth Subbasin point toward the increasing awareness of the need of local leadership for such action. Zoning is an effective and workable way to prevent random, undesirable land use development and to help make the best use of the shrinking land resource.

Some of the advantages of zoning include:

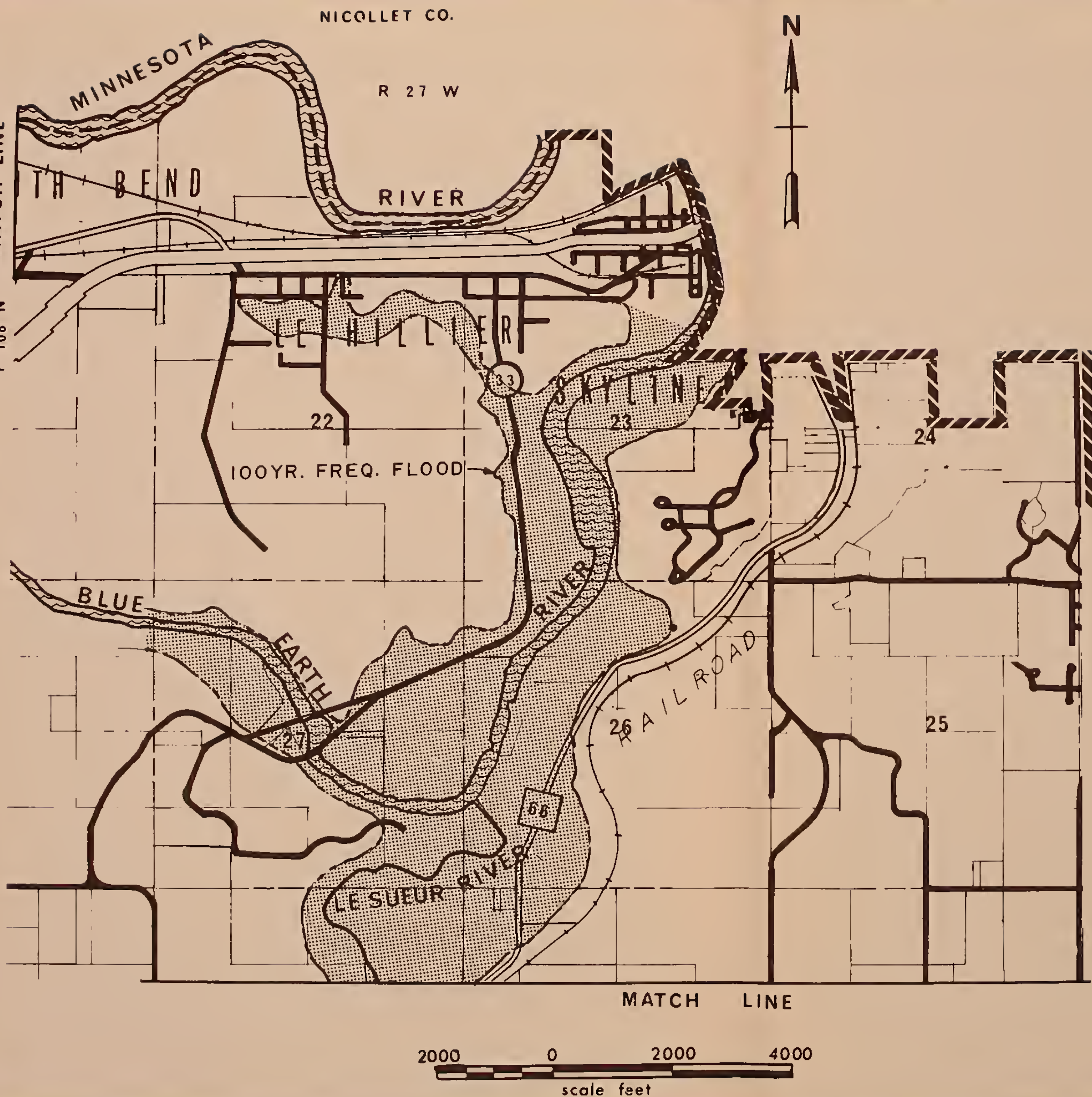
(1) Provision for the orderly growth of a town or county.
(2) Protection of land and property value by prohibiting undesirable uses of adjacent property.
(3) Lower cost of public services such as roads and utilities.
(4) A better physical environment by requiring that unsightly uses of land, such as junk yards, be screened or eliminated.

Things that zoning cannot do include:

(1) Correct many problems which already exist.
(2) Increase the freedom of the individual to do whatever he wants to do with his property.
(3) Reduce the number of regulations and rules which must be observed.

In order to avoid these problems, it is obvious that the care taken in planning a zoning ordinance is of great importance. Good zoning ordinance must be based on intensive, careful planning which considers the total resource at hand. The interest of all groups and individuals must be objectively evaluated. Based on a good foundation, zoning makes possible the grouping of compatible land uses and segregation of incompatible uses.

Land use control and zoning are carried to restrictive extremes in many European Countries. Such action is looked upon as undesirable in the United States with the exception of Hawaii. As an example, the polynesian history and culture of Hawaii makes possible the acceptance of such regulations. In Hawaii agricultural land is preserved. Urban development is restricted, and there is little room for compromise. Hawaii uses a strong zoning system carried out by the state government. Site evaluation is made to determine the need for various development. From this comes



BLUE EARTH RIVER SUBBASIN
BLUE EARTH CO., MINN.
100YR. FREQUENCY
FLOOD DELINEATION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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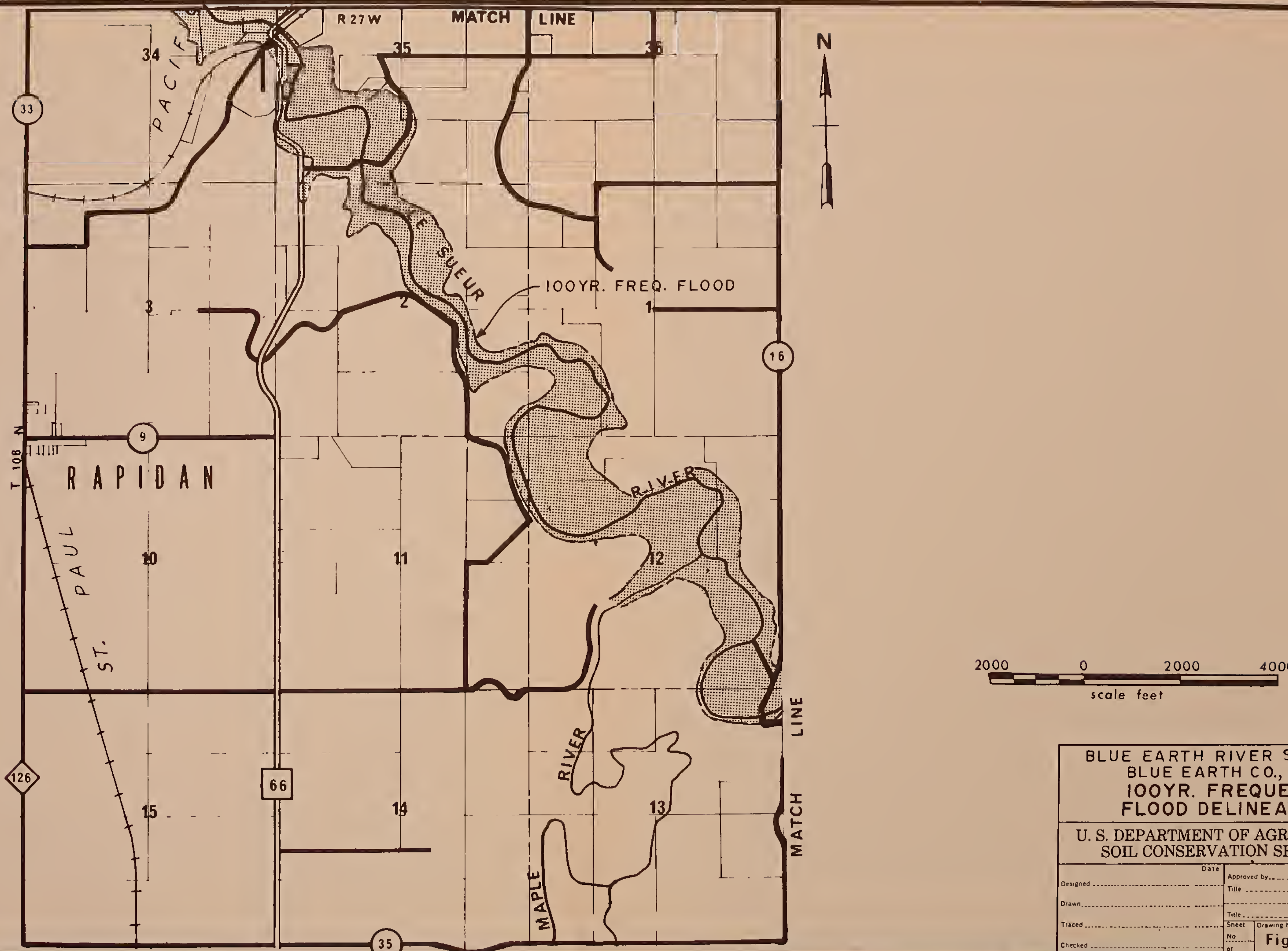

BLUE EARTH RIVER SUBBASIN
BLUE EARTH CO., MINN.
100YR. FREQUENCY
FLOOD DELINEATION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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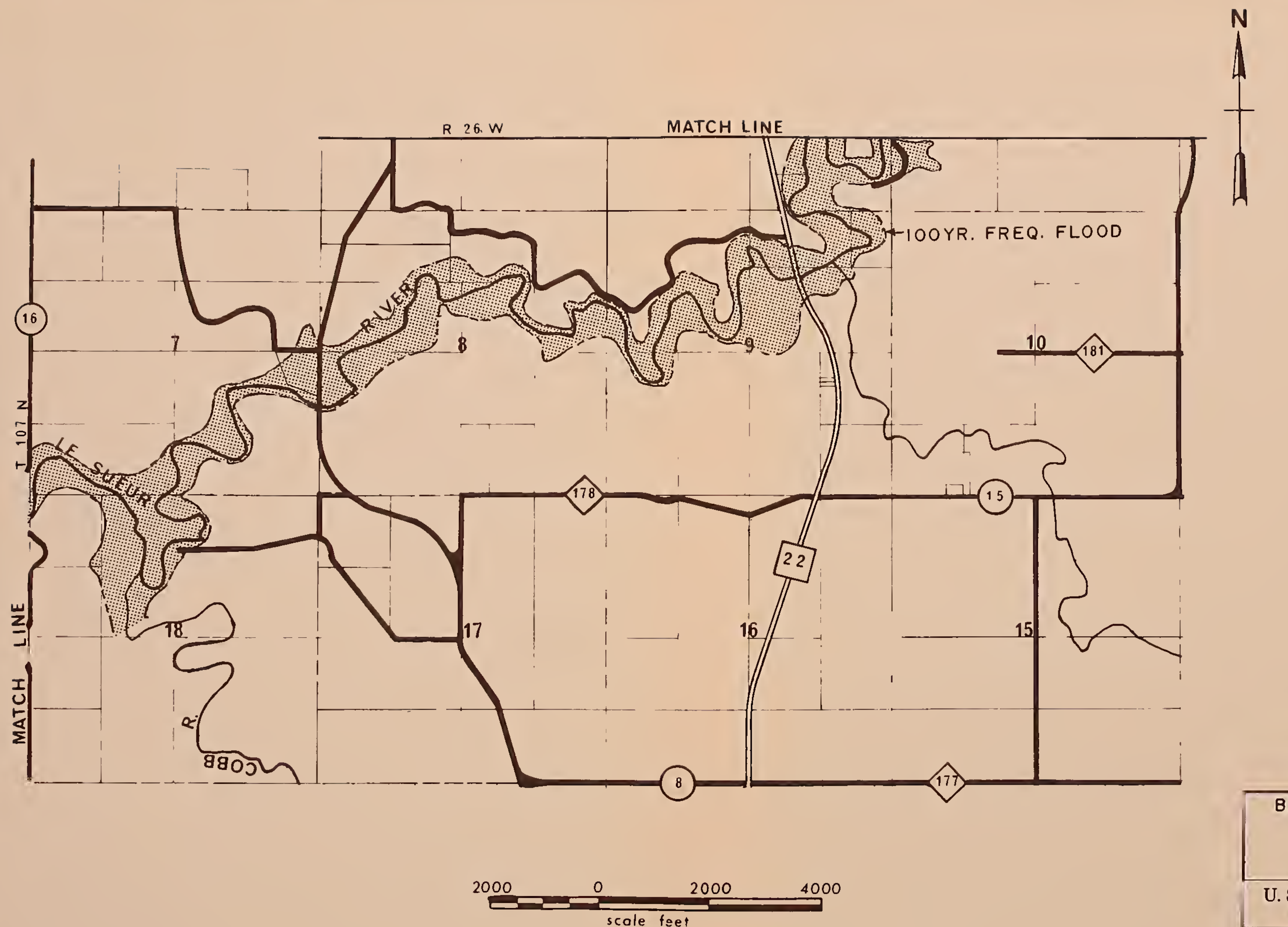

BLUE EARTH RIVER SUBBASIN
BLUE EARTH CO., MINN.
100YR. FREQUENCY
FLOOD DELINEATION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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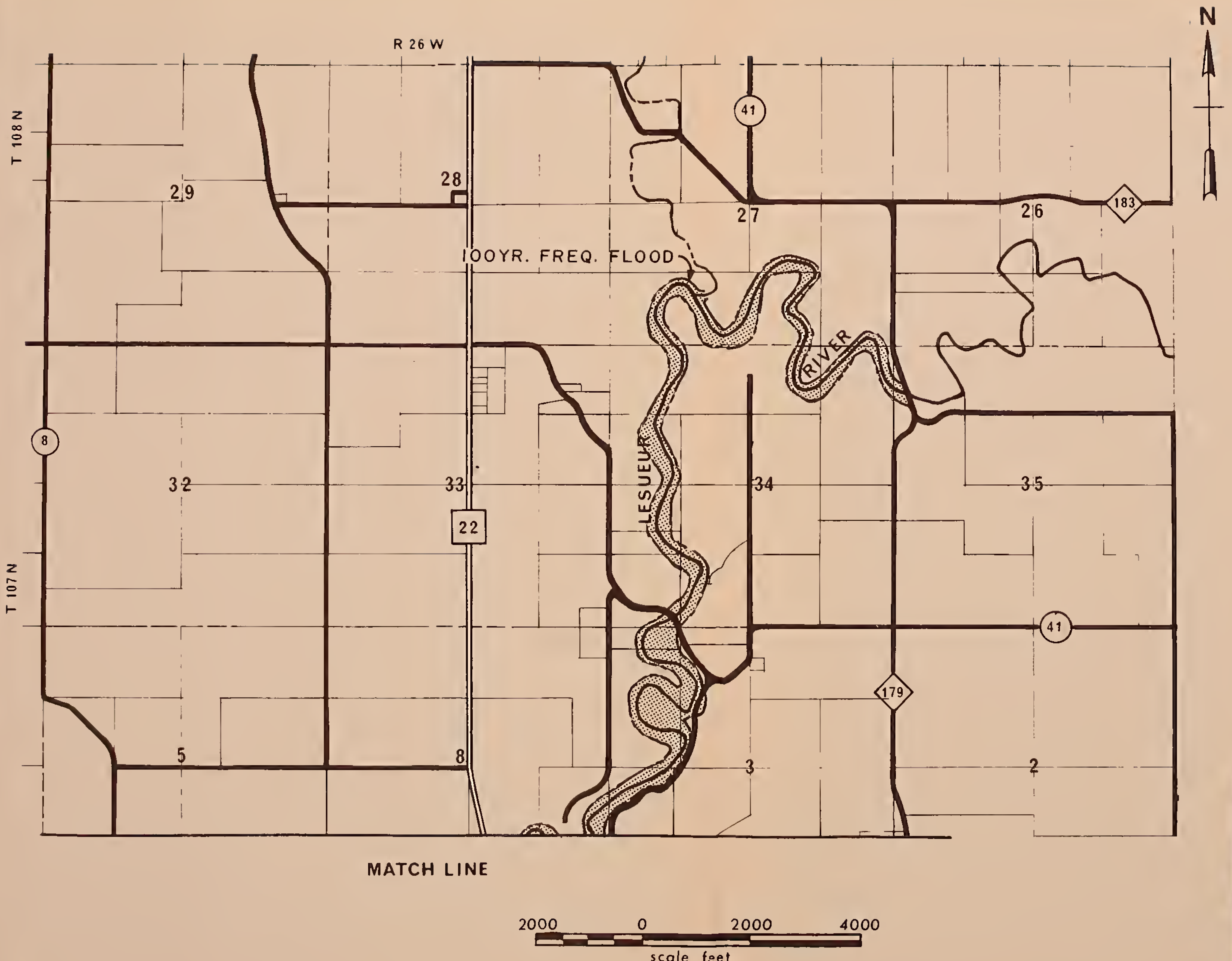

BLUE EARTH RIVER SUBBASIN
BLUE EARTH CO., MINN.
100YR. FREQUENCY
FLOOD DELINEATION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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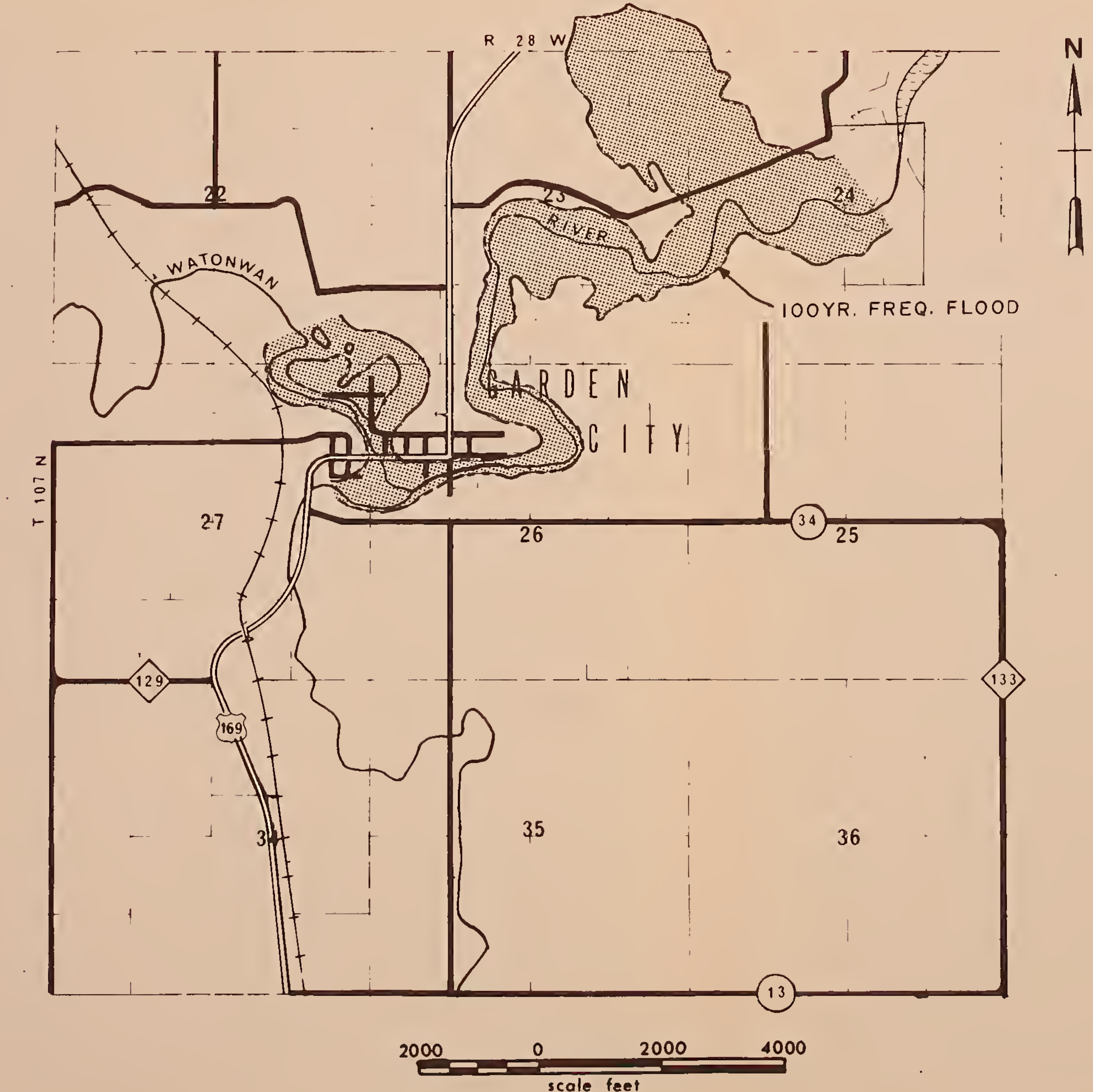

BLUE EARTH RIVER SUBBASIN
BLUE EARTH CO., MINN.

100YR. FREQUENCY FLOOD DELINEATION

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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the knowledge of exactly where and when the next type of development will occur. The pattern of zoning in Hawaii would be considered very restrictive by Minnesota standards. Imagine a freeway winding through the countryside with extensive urban development on one side and a purely agricultural setting on the other side with only farmers' homes. Such a pattern has been established with strict, no compromise zoning. Cities which must grow are directed to new areas as the need develops. Hawaiians use their system to preserve agriculture and areas of natural beauty - facilitated by statewide agricultural and conservation districts along with rigid zoning practices.

There may be something to be learned from European and Hawiian land use regulations. Although adoption of such restrictive regulations may not be desirable in the Blue Earth Subbasin, more restrictive regulations should be considered. It would be sad to look back 50 years from now and realize that a better life could have been achieved for the current and future generations if more thoughtful land use planning had been invested in.

10. Land Treatment Potential

Needed land treatment can be implemented through Public Law 46 and cooperative forestry programs. Technical assistance for the establishment of land treatment practices is provided through such agencies as the Soil Conservation Service and the Forest Service. Cost sharing on land treatment practices with landowners can be provided through the Rural Environmental Assistance Program which is administered by the Agricultural Stabilization and Conservation Service.

Specific areas which present the opportunity for development of land treatment measures are:

<u>Cropland</u>

For drainage of excess water such measures as tile drains and open ditches would be required to reduce the problems. This would result in better quality and quantity crops as well as allow the use of land earlier in the year on 613,500 acres. On approximately 230,000 acres where erosion is a problem contouring, strip cropping, terraces and diversions would help reduce soil loss.

<u>Pasture</u>

A total of 57,900 acres of pasture needs land treatment measures to increase productivity. Simple, low cost management practices such as brush control, protection

from overgrazing or improvement of present cover would result in much greater yield per acre. Some 900 acres of land now used for pasture could better be used for tree production.

Table 7.2 summarizes the cropland and pasture land treatment situation for the Blue Earth Subbasin. Estimated cost to complete necessary land treatment measures on crop and pasture lands is also shown.

Table 7.2

Land Treatment Needs and Costs
Blue Earth River Subbasin

CROPLAND NEEDS	Acres	Costs
Land Adequately Treated	436,280	$ 1,031
Crop Residue, Annual Cover Crops	294,610	1,031
Sod in Crop Rotation	276,870	415
Contouring Only	104,720	157
Strip Cropping, Terraces and Diversions	129,660	4,408
Change in Land Use	9,980	247
Adequate Drainage System	613,500	107,363
Total	1,865,520	
PASTURE AND RANGELAND NEEDS		
Pasture or Rangeland Adequately Treated	10,470	0
Pasture or Rangeland not Feasible to Treat	10,310	0
Protection of Plant from Overgrazing	22,800	0
Improvement of Present Plant Cover	15,920	143
Brush Control	1,120	4
Reestablishment of Vegetative Cover	4,100	41
Reestablishment of Vegetative Cover and Brush Control	2,740	38
Change in Land Use to Trees	910	137
Total	68,370	

Source: From 1967 Conservation Needs Inventory

APPENDIX NO. 1
INTERIM REPORT

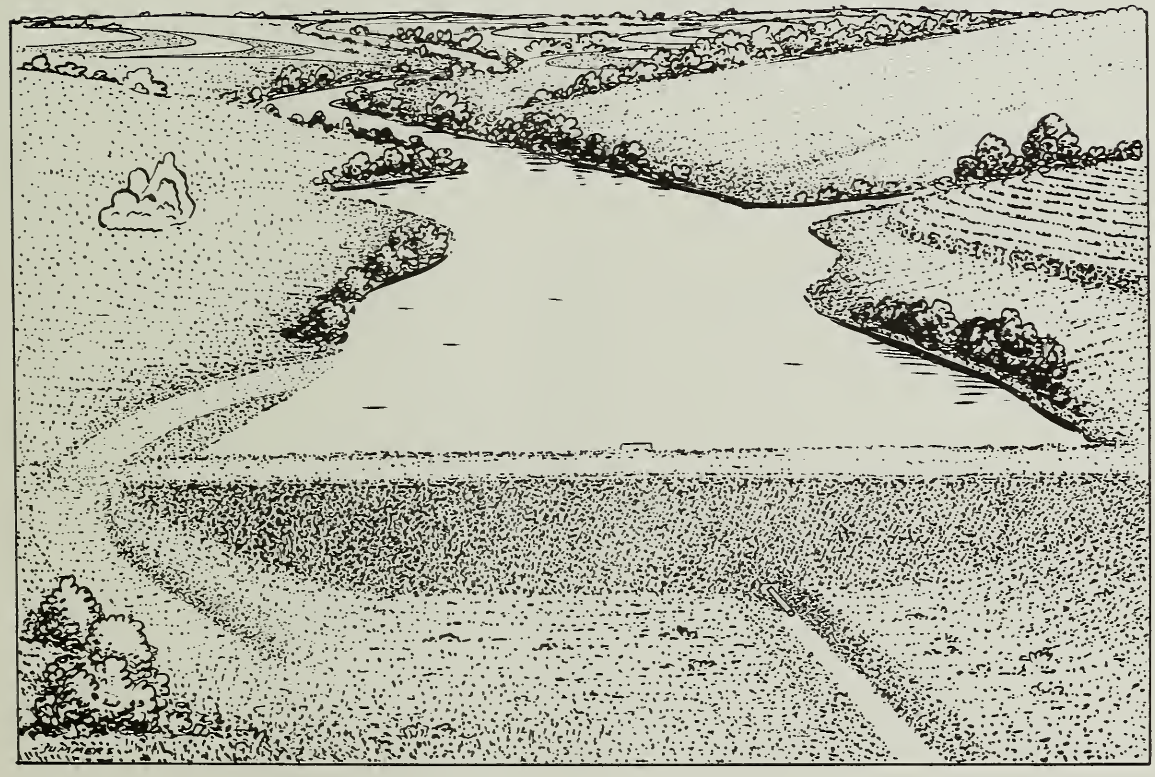
BLUE EARTH RIVER SUBBASIN

of the

MINNESOTA RIVER BASIN

portion of the

SOUTHERN MINNESOTA RIVERS BASIN STUDY



UPSTREAM RESERVOIR SITE INVENTORY

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

1971

USDA-SCS-LINCOLN, NEBR. 1971

UPSTREAM RESERVOIR
SITE INVENTORY

STUDY AREA I - BLUE EARTH RIVER SUBBASIN
of the
MINNESOTA RIVER BASIN
portion of the
SOUTHERN MINNESOTA RIVERS BASIN STUDY

MINNESOTA, SOUTH DAKOTA, AND IOWA

BLUE EARTH RIVER BASIN UPSTREAM RESERVOIR STUDY

INTRODUCTION

This is an inventory of water storage opportunities in upstream watersheds in the Blue Earth River Basin. The information presented was gathered and developed by the Soil Conservation Service. The report contains preliminary data on 119 tentative reservoir sites with additional data on 76 of these sites which have floodwater storage capacity.

The purpose of this report is to summarize the potential of upstream structures in the Blue Earth Basin for (1) floodwater storage (2) other beneficial uses. More intensive investigations should be made to substantiate topographic and geologic data before sites are selected for detailed planning and development. The inventory reflects only the physical potential for storage in the basin, and economic justification of sites is not implied.

Study Procedure

(1) Site Selection

One hundred and nineteen tentative reservoir sites were selected for evaluation by a study of USGS topographic maps and from suggestions made by interested persons. In general sites were limited to drainage areas of 100 square miles or less. A few sites were included with drainage areas exceeding this limit where storage potential appeared to be good or interest was indicated in a specific site.

Significant effects on railroads, interstate highways, main state highways, towns, and concentrations of buildings were avoided in selecting sites. Individual farmsteads and other roads were not considered to be prohibitive factors.

Sites are numbered according to the Conservation Needs Inventory watershed unit designations. Blue Earth River tributaries begin with 8e. The Watonwan River area is 8e1, and the Le Sueur River is 8e2. Locations of sites evaluated are shown on the accompanying site inventory map.

(2) Structure Study and Evaluation

Areas inundated and available storage for each site were determined from USGS maps. A representative group of sites were investigated in detail to establish reservoir storage requirements for floodwater detention. The tentative sites were then screened and those having storage adequate for floodwater detention were selected for further analysis.

Preliminary designs were made for 76 sites showing floodwater storage potential. Where additional storage was available several levels of development were considered for the site. Structure locations for these sites are shown on detail maps and the storage curves are included. Structure data appear in Table 1. Since some of these are alternates on the same stream, use of certain sites would eliminate development of others.

Reservoir storage includes sediment, beneficial use, and temporary floodwater. Sediment volume was estimated for a 100 year period. Beneficial storage includes all permanent storage except sediment for any desired purpose. Temporary floodwater storage is normally from two to four inches runoff from the watershed.

All structures were assumed to have unregulated fixed spillways designed for at least moderate hazard conditions. Spillway discharges were kept low for the first inch of floodwater storage, and the maximum discharges were varied as required by available storage. A minimum vertical distance of two feet was assumed between the permanent pool and emergency spillway elevations.

A field reconnaissance was made of about 50 percent of the sites shown on Table 1. A surface investigation of 30 larger sites was made by a geologist to determine if there were any apparent geologic conditions that would affect the water holding capability or cause foundation problems.

Some sites are located on areas where evidence of considerable amounts of sand and gravel deposits were found. In other areas muck and swamp soil could present problems. Of the sites investigated about seventy percent are considered as good possibilities for holding water. Twenty percent of them have fair water holding possibilities. Ten percent of them had poor foundation conditions which could require more than average foundation repair costs. Where permanent water holding ability is not a requirement ninety percent of the sites are considered as good.

Sites not considered adequate for flood prevention are shown in Table 2. Although not investigated beyond a storage determination, some of these sites may be useful for other purposes. Suitability of individual sites was not determined for specific beneficial use.

(3) Cost of Reservoirs

Although no reservoir costs are shown in this report, estimated construction costs are available at the Soil Conservation Service office in St. Paul, Minnesota for those sites shown in Table 1. Based on preliminary designs, quantities were determined and current unit prices applied to the major construction items for 30 structures.

An average cost curve was developed from this data on the basis of drainage area controlled. It was used to estimate construction costs of the remaining structures with floodwater storage potential.

This cost curve is included and may be used for a first estimate of construction cost for Table 1 sites. Land areas required for the sites are shown in the top-of-dam acres column of the table.

Data Limitations

Despite the detail indicated in the reporting of suface acres, elevations, storage, fill height and yardage, it must be emphasized that the data was obtained from computation based solely on USGS $7\frac{1}{2}$ minute or 15 minute topographic maps. Field surveys were not made. It must be further emphasized that data reflects potential for development rather than actual design characteristics.

TABLE 1

STRUCTURE DATA FOR POTENTIAL RESERVOIR SITES FOR FLOOD PREVENTION AND MULTIPURPOSE USE
STUDY AREA 1 - BLUE EARTH RIVER BASIN

Site No.	Drainage Area (Sq. Mi.)	ELEVATION Top Dam	ELEVATION Ben. Use Pool	STORAGE Sediment (Ac. Ft.)	STORAGE Temporary Floodwater (Ac. Ft.)	STORAGE Temporary Floodwater (Inches)	STORAGE Ben. Use (Ac.Ft.)	STORAGE Total (Ac. Ft.)	STORAGE Total (Inches)	AREA Top Dam (Ac)	AREA Ben. Use Pool (Ac)	FILL Max. Ht. (Ft.)	FILL Volume (Cu. Yd.)	Site Shown on Map Figure
8e-03-1	5.6	1078	-	60	550	1.8	-	610	2.0	180	-	31	35,000	59
8e-03-10	2.0	973	-	30	340	3.2	-	370	3.4	220	-	11	2,000	8
8e-03-13	1.8	1070	1065	20	180	1.9	870	1070	11.2	160	100	42	105,000	38
		1060	1050	20	180	1.9	180	380	4.0	50	20	32	26,000	
		1053	-	20	180	1.9	-	200	2.1	30	-	25	10,000	
8e-03-14	0.7	1085	1080	10	90	2.4	230	330	8.8	75	30	33	86,000	59
		1079	1070	10	80	2.1	40	130	3.3	30	7	27	49,000	
		1076	-	10	80	2.1	-	90	2.3	20	-	24	25,000	
8e-11-10	7.4	1219	-	70	930	2.3	-	1000	2.5	210	-	15	9,000	62
8e-13-1	14.1	1220	1212	380	2340	3.1	3710	6430	8.6	690	530	28	100,000	61
		1213	-	380	2340	3.1	-	2720	3.6	550	-	21	51,000	
8e-13-10	3.0	1090	1083	30	530	3.3	740	1300	8.1	200	130	23	44,000	60
		1087	1079	30	530	3.3	250	810	5.1	160	75	20	34,000	
		1085	-	30	530	3.3	-	560	3.5	150	-	18	26,000	
8e-14-1	111.4	1080	-	610	10730	1.8	-	11340	1.9	910	-	45	274,000	57
8e-14-10	1.1	1170	1165	10	130	2.2	130	270	4.6	95	35	22	28,000	56
		1167	-	10	130	2.2	-	140	2.4	60	-	19	25,000	
8e-15-1[1/]	18.0	1189	-	670	1340	1.4	-	2010	2.1	310	-	37	50,000	55

TABLE 1

STRUCTURE DATA FOR POTENTIAL RESERVOIR SITES FOR FLOOD PREVENTION AND MULTIPURPOSE USE
STUDY AREA 1 - BLUE EARTH RIVER BASIN

Site No.	Drainage Area (Sq. Mi.)	ELEVATION Top Dam	ELEVATION Ben. Use Pool	STORAGE Sediment (Ac. Ft.)	STORAGE Temporary Floodwater (Ac. Ft.)	STORAGE Temporary Floodwater (Inches)	STORAGE Ben. Use (Ac.Ft.)	STORAGE Total (Ac. Ft.)	STORAGE Total (Inches)	AREA Top Dam (Ac)	AREA Ben. Use Pool (Ac)	FILL Max. Ht. (Ft.)	FILL Volume (Cu. Yd.)	Site Shown on Map Figure
8e-15-10	0.7	1205	1200	10	170	4.6	440	620	16.7	60	40	32	80,000	54
		1193	1182	10	100	2.6	70	180	4.7	20	15	20	17,000	
		1189	-	10	100	2.6	-	110	2.8	20	-	16	9,000	
8e-17-3	76.1	1304	-	810	7690	1.9	-	8500	2.1	960	-	39	324,000	26
8e-17-5	12.3	1134	1127	0 2/	2130	3.2	4390	6520	9.9	800	590	21	112,000	36
		1126	-	0	2130	3.2	-	2130	3.2	570	-	13	40,000	
8e-17-6	8.75	1138	1127	0 2/	1360	2.9	1040	2400	5.2	250	170	21	19,000	36
		1133	-	0	1360	2.9	-	1360	2.9	220	-	16	10,000	
8e-17-10	2.5	1400	1397	20	400	3.0	140	560	4.2	90	40	22	21,000	52
		1398	-	20	400	3.0	-	420	3.2	80	-	20	16,000	
8e-17-11	2.5	1410	1405	30	450	2.7	630	1110	6.7	260	140	20	20,000	52
		1408	1401	30	450	2.7	240	720	4.3	220	75	18	14,000	
		1406	-	30	450	2.7	-	480	2.9	160	-	16	11,000	
8e-17-12	1.9	1270	1265	30	320	3.2	1090	1440	14.2	180	150	19	14,000	53
		1264	1260	30	270	2.7	300	600	3.6	150	110	13	5,000	
		1261	-	30	270	2.7	-	300	2.9	130	-	10	2,000	
8e-17-15	2.0	1395	1389	20	410	3.8	870	1300	12.2	190	120	33	58,000	18
		1389	1380	20	340	3.2	230	590	5.4	120	40	27	30,000	
		1386	-	20	340	3.2	-	360	3.4	85	-	24	22,000	

TABLE 1

STRUCTURE DATA FOR POTENTIAL RESERVOIR SITES FOR FLOOD PREVENTION AND MULTIPURPOSE USE
STUDY AREA 1 - BLUE EARTH RIVER BASIN

Site No.	Drainage Area (Sq. Mi.)	ELEVATION		STORAGE						AREA		FILL		Site Shown on Map Figure
		Top Dam	Ben. Use Pool	Sediment (Ac. Ft.)	Temporary Floodwater (Ac. Ft.)	Temporary Floodwater (Inches)	Ben. Use (Ac. Ft.)	Total (Ac.Ft.)	Total (Inches)	Top Dam (Ac)	Ben. Use Pool (Ac)	Max. Ht. (Ft.)	Volume (Cu. Yd.)	
8e-17-16	3.5	1395	1388	40	600	3.2	1360	2000	10.7	240	150	35	155,000	18
		1389	1379	40	600	3.2	350	990	5.5	160	70	29	108,000	
		1385	-	40	600	3.2	-	640	3.4	120	-	25	54,000	
8e-17-17	1.3	1190	1183	10	210	3.0	190	410	5.9	80	40	20	35,000	31
		1187	-	10	210	3.0	-	220	3.2	60	-	17	27,000	
8e-18-1	10.6	1015	-	110	1700	3.0	-	1810	3.2	680	-	15	9,000	34
8e-18-2.1	64.9	1020	-	690	6350	1.8	-	7040	2.0	890	-	42	191,000	37
8e-18-10	4.1	1104	997	40	660	3.0	2540	3240	14.8	460	310	31	100,000	33
		998	992	40	660	3.0	1110	1810	8.3	330	230	25	57,000	
		994	-	40	660	3.0	-	700	3.2	260	-	21	26,000	
8e-18-10.1	1.9	1000	996	20	300	3.0	1350	1670	16.5	340	260	17	45,000	33
		996	992	20	300	3.0	510	830	8.2	260	150	13	28,000	
		993	-	20	300	3.0	-	320	3.2	170	-	10	22,000	
8e-18-13.1	1.8	1017	-	20	230	2.4	-	250	2.6	140	-	10	10,000	34
8e1-01-1	11.7	1410	1395	100	2440	3.9	160	2700	4.3	560	100	19	23,000	16
8e1-01-2	31.0 3/	1361	1340	200	4200	2.5	1050	5450	3.3	430	170	41	65,000	17
		1358	-	200	4200	2.5	-	4400	2.7	380	-	38	58,000	
8e1-01-3	82.1 3/	1177	-	300	8050	1.8	-	8350	1.9	1240	-	41	248,000	5

TABLE 1

STRUCTURE DATA FOR POTENTIAL RESERVOIR SITES FOR FLOOD PREVENTION AND MULTIPURPOSE USE
STUDY AREA 1 - BLUE EARTH RIVER BASIN

Site No.	Drainage Area (Sq. Mi.)	ELEVATION		STORAGE						AREA		FILL		Site Shown on Map Figure
		Top Dam	Ben. Use Pool	Sediment (Ac. Ft.)	Temporary Floodwater (Ac. Ft.)	Temporary Floodwater (Inches)	Ben. Use (Ac. Ft.)	Total (Ac.Ft.)	Total (Inches)	Top Dam (Ac)	Ben. Use Pool (Ac)	Max. Ht. (Ft.)	Volume (Cu. Yd.)	
8e1-01-4	14.0	1300	-	80	1720	2.3	-	1800	2.4	260	-	48	95,000	4
8e1-01-5	11.2	1251	-	50	2100	3.5	-	2150	3.6	360	-	42	60,000	2
8e1-01-6	33.8 3/	1196	-	100	3650	2.0	-	3750	2.1	600	-	36	68,000	3
8e1-01-13	3.8	1460	1455	40	590	2.9	550	1180	5.8	400	180	15	32,000	1
		1458	-	40	600	3.0	-	640	3.2	280	-	13	27,000	
8e1-01-14	2.7	1420	-	30	260	1.8	-	290	2.0	40	-	23	46,000	16
8e1-02-1	5.7	1205	-	60	820	2.7	-	880	2.9	160	-	20	69,000	22
8e1-02-2	10.6	1204	-	110	1400	2.5	-	1510	2.7	230	-	25	56,000	22
8e1-02-3	7.1	1097	-	0 2/	1030	2.7	-	1030	2.7	410	-	10	19,000	6
8e1-03-1	14.3	1140	1131	0 2/	2620	3.4	1380	4000	5.2	620	450	15	36,000	27
		1137	-	0	2620	3.4	-	2620	3.4	570	-	12	21,000	
8e1-03-10	5.3	1180	1173	60	820	2.9	480	1360	4.8	360	130	20	33,000	23
		1178	-	60	820	2.9	-	880	3.1	270	-	18	23,000	
8e1-06-1.1	22.5	1340	1325	240	3820	3.2	4240	8300	6.9	500	330	48	64,000	19
		1335	1318	240	3820	3.2	2140	6200	5.2	440	260	43	48,000	
		1330	-	240	3820	3.2	-	4060	3.4	390	-	38	36,000	

TABLE 1

STRUCTURE DATA FOR POTENTIAL RESERVOIR SITES FOR FLOOD PREVENTION AND MULTIPURPOSE USE
STUDY AREA 1 - BLUE EARTH RIVER BASIN

Site No.	Drainage Area (Sq. Mi.)	ELEVATION Top Dam	ELEVATION Ben. Use Pool	STORAGE Sediment (Ac. Ft.)	STORAGE Temporary Floodwater (Ac. Ft.)	STORAGE Temporary Floodwater (Inches)	STORAGE Ben. Use (Ac. Ft.)	STORAGE Total (Ac.Ft.)	STORAGE Total (Inches)	AREA Top Dam (Ac)	AREA Ben. Use Pool (Ac)	FILL Max. Ht. (Ft)	FILL Volume (Cu. Yd.)	Site Shown on Map Figure
8e1-06-2	31.6	1299	-	260	5420	3.2	-	5680	3.4	490	-	40	140,000	20
8e1-07-1.1	17.7	1330	-	140	2180	2.3	-	2320	2.5	300	-	41	131,000	21
8e1-07-3 3/	52.2	1212	1195	220 2/	4470	1.6	570	5260	1.9	510	250	26	111,000	24
		1210	-	220	4470	1.6	-	4690	1.7	470	-	24	93,000	
8e1-07-4 3/	96.0	1205	-	0 2/	9420	1.8	-	9420	1.8	1150	-	26	46,000	25
8e1-07-10	1.3	1200	1196	10	240	3.5	670	920	13.2	160	120	17	11,000	29
		1197	1192	10	240	3.5	260	510	7.5	130	80	14	8,000	
		1194	-	10	210	3.0	-	220	3.2	100	-	11	6,000	
8e1-08-2	28.8	1140	-	320	3290	2.2	-	3610	2.4	440	-	46	160,000	30
8e1-11-1	15.5	1056	-	160	1670	2.0	-	1830	2.2	620	-	18	41,000	32
8e1-11-10	0.9	1069	1065	10	240	5.0	480	730	15.2	140	100	14	12,000	28
		1064	1060	10	150	3.1	80	240	4.9	100	60	9	6,000	
		1063	-	10	130	2.7	-	140	2.9	90	-	8	5,000	
8e1-12-1 4/	23.4	1102	1090	260	2650	2.1	1250	4160	3.3	700	230	28	209,000	35
		1099	-	260	2650	2.1	-	2910	2.3	640	-	25	176,000	
8e1-13-10	2.6	990	984	30	550	4.0	1180	1760	12.7	280	160	30	48,000	7
		984	976	30	430	3.0	330	790	5.5	160	90	24	28,000	
		980	-	30	430	3.0	-	460	3.2	110	-	20	14,000	

TABLE 1

STRUCTURE DATA FOR POTENTIAL RESERVOIR SITES FOR FLOOD PREVENTION AND MULTIPURPOSE USE
STUDY AREA 1 - BLUE EARTH RIVER BASIN

Site No.	Drainage Area (Sq. Mi.)	ELEVATION		STORAGE						AREA		FILL		Site Shown on Map Figure
		Top Dam	Ben. Use Pool	Sediment (Ac. Ft.)	Temporary Floodwater (Ac. Ft.)	Temporary Floodwater (Inches)	Ben. Use (Ac. Ft.)	Total (Ac. Ft.)	Total (Inches)	Top Dam (Ac)	Ben. Use Pool (Ac)	Max. Ht. (Ft.)	Volume (Cu. Yd.)	
8e2-01-1	51.7	1190	-	260	6200	1.9	-	6460	2.0	800	-	36	197,000	49
8e2-01-3	9.8	989	-	30 2/	1920	3.6	-	1950	3.7	790	-	11	8,000	12
8e2-01-10	1.6	1008	-	20	170	2.0	-	190	2.2	340	-	8	2,800	9
8e2-01-11	1.9	985	980	20	790	8.5	1260	2070	20.7	480	380	17	38,000	10
		983	977	20	470	4.7	470	960	9.7	450	220	15	30,000	
		981	-	20	350	3.5	-	370	3.7	420	-	13	22,000	
8e2-01-12	2.6	980	972	10	290	2.0	300	600	4.3	160	75	20	37,000	9
		979	-	10	500	3.5	-	510	3.7	150	-	19	35,000	
8e2-01-14	3.7	1115	-	40	690	3.5	-	730	3.7	520	-	13	8,000	11
8e2-01-15	5.7	1000	-	70	530	1.8	-	600	2.0	550	-	15	10,000	12
8e2-01-17	1.2	1240	1232	20	220	3.5	380	620	9.8	170	60	30	111,000	50
		1237	1233	20	220	3.5	190	430	6.7	120	35	27	65,000	
		1234	-	20	220	3.5	-	240	3.7	80	-	24	49,000	
8e2-01-18	3.2	1230	1220	30	600	3.5	790	1420	8.3	170	100	30	33,000	51
		1226	1215	30	600	3.5	370	1000	5.9	140	65	26	18,000	
		1223	-	30	600	3.5	400	630	3.7	120	-	23	12,000	
8e2-04-10	2.7	1090	1078	30	430	3.0	200	660	4.6	110	40	27	71,000	14
		1087	-	30	430	3.0	-	460	3.2	90	-	24	50,000	

TABLE 1

STRUCTURE DATA FOR POTENTIAL RESERVOIR SITES FOR FLOOD PREVENTION AND MULTIPURPOSE USE
STUDY AREA 1 - BLUE EARTH RIVER BASIN

Site No.	Drainage Area (Sq. Mi.)	ELEVATION Top Dam	ELEVATION Ben. Use Pool	STORAGE Sediment (Ac. Ft.)	STORAGE Temporary Floodwater (Ac. Ft.)	STORAGE Temporary Floodwater (Inches)	STORAGE Ben. Use (Ac. Ft.)	STORAGE Total (Ac. Ft.)	STORAGE Total (Inches)	AREA Top Dam (Ac)	AREA Ben. Use Pool (Ac)	FILL Max. Ht. (Ft.)	FILL Volume (Cu. Yd.)	Site Shown on Map Figure
8e2-04-11	2.3	1120	1114	30	440	3.5	1220	1690	13.7	380	260	18	3,000	14
		1118	1111	30	440	3.5	600	1070	8.7	340	210	16	2,000	
		1115	-	30	440	3.5	-	470	3.7	290	-	12	1,000	
8e2-04-12	3.0	1180	1069	30	480	3.0	370	880	5.5	150	60	30	15,000	15
		1078	1065	30	480	3.0	170	680	4.2	130	35	28	12,000	
		1076	-	30	480	3.0	-	510	3.2	110	-	26	10,000	
8e2-06-1	3.9	1063	1058	0 2/	1000	4.8	2400	3400	16.3	540	470	15	4,000	47
		1060	1055	0	900	4.3	1050	1950	9.3	500	410	12	3,000	
		1057	-	0	750	3.6	-	750	3.6	450	-	9	2,000	
8e2-06-2	21.4	1063	-	20 2/	4000	3.6	-	4020	3.6	930	-	15	10,000	47
8e2-06-4	6.9	1025	1020	100	1280	3.5	640	2020	5.5	1010	560	10	16,000	41
		1024	-	100	1110	3.0	-	1210	3.3	920	-	9	13,000	
8e2-06-5	65.9	1024	-	420 2/	9040	2.6	-	9460	2.7	2300	-	19	14,000	40
8e2-06-10	4.0	1010	1005	40	750	3.5	600	1390	6.5	360	170	20	12,000	39
		1008	994	40	750	3.5	260	1050	4.9	310	110	18	10,000	
		1007	-	40	750	3.5	-	790	3.7	280	-	17	9,000	
8e2-06-11	2.4	989	983	0 2/	870	6.7	1560	2430	18.7	520	430	14	15,000	39
		987	981	0	840	6.5	710	1550	12.0	500	400	12	8,000	
		984	-	0	450	3.7	-	450	3.7	460	-	11	6,000	

TABLE 1

STRUCTURE DATA FOR POTENTIAL RESERVOIR SITES FOR FLOOD PREVENTION AND MULTIPURPOSE USE
STUDY AREA 1 - BLUE EARTH RIVER BASIN

		ELEVATION		STORAGE						AREA		FILL		
Site No.	Drainage Area (Sq. Mi.)	Top Dam	Ben. Use Pool	Sediment (Ac. Ft.)	Temporary Floodwater (Ac. Ft.)	Temporary Floodwater (Inches)	Ben. Use (Ac. Ft.)	Total (Ac. Ft.)	Total (Inches)	Top Dam (Ac.)	Ben. Use Pool (Ac.)	Max. Ht. (Ft.)	Volume (Cu. Yd.)	Site Shown on Map Figure
8e2-06-12	.9	1000	994	10	140	3.0	570	720	15.0	100	75	22	47,000	39
		997	989	10	140	3.0	280	430	9.0	85	55	19	35,000	
		992	-	10	140	3.0	-	150	3.2	65	-	14	20,000	
8e2-06-17	1.4	1060	1052	10	260	3.5	300	570	7.7	180	80	18	35,000	46
		1058	1049	10	260	3.5	100	370	5.1	150	40	16	27,000	
		1056	-	10	260	3.5	-	270	3.7	130	-	14	21,000	
8e2-07-1	29.1	1174	-	290	3780	2.4	-	4070	2.6	580	-	39	300,000	48
8e2-07-3	4.5	1045	1038	50	740	3.1	1270	2060	8.6	230	170	21	8,000	43
		1043	1035	50	740	3.1	830	1620	6.8	210	150	19	6,000	
		1038	-	50	740	3.1	-	790	3.3	170	-	14	3,000	
8e2-07-10	2.0	1000	993	0 2/	670	6.2	630	1300	12.2	430	320	15	14,000	13
		997	990	0	400	3.7	220	620	5.7	350	150	12	9,000	
		996	-	0	400	3.7	-	400	3.7	320	-	11	7,000	
8e2-07-11	2.1	1019	1012	0 2/	600	5.3	1230	1820	16.3	350	280	16	28,000	42
		1015	-	0	560	5.0	-	560	5.0	310	-	12	14,000	
8e2-07-12	0.1	1035	1028	1	20	3.5	10	30	5.4	30	6	10	10,000	44
8e2-09-10	.8	1083	1076	10	170	4.0	500	680	16.0	110	75	32	60,000	58
		1082	-	10	150	3.5	-	160	3.7	110	-	31	55,000	

TABLE 1

STRUCTURE DATA FOR POTENTIAL RESERVOIR SITES FOR FLOOD PREVENTION AND MULTIPURPOSE USE
STUDY AREA 1 - BLUE EARTH RIVER BASIN

Site No.	Drainage Area (Sq. Mi.)	ELEVATION		STORAGE						AREA		FILL		Site Shown on Map Figure
		Top Dam	Ben. Use Pool	Sediment (Ac. Ft.)	Temporary Floodwater (Ac. Ft.)	Temporary Floodwater (Inches)	Ben. Use (Ac. Ft.)	Total (Ac. Ft.)	Total (Inches)	Top Dam (Ac.)	Ben. Use Pool (Ac.)	Max. Ht. (Ft.)	Volume (Cu. Yd.)	
8e2-11-10	2.5	1089	1081	30	470	3.5	360	860	6.4	130	100	18	64,000	45
		1088	1080	30	470	3.5	260	760	5.7	130	100	17	32,000	
		1086	-	30	470	3.5	-	500	3.7	120	-	16	26,000	

1/ Structure 8e-15-1 is primarily for sediment detention.

2/ Estimated volume of existing lake utilized for sediment requirements.

3/ Design assumes upstream structures in series.

4/ Structure 8e1-12-1 assumes Mink Creek diverted into Perch Creek.

TABLE 2

OTHER SITES EVALUATED

STUDY AREA 1 - BLUE EARTH RIVER BASIN

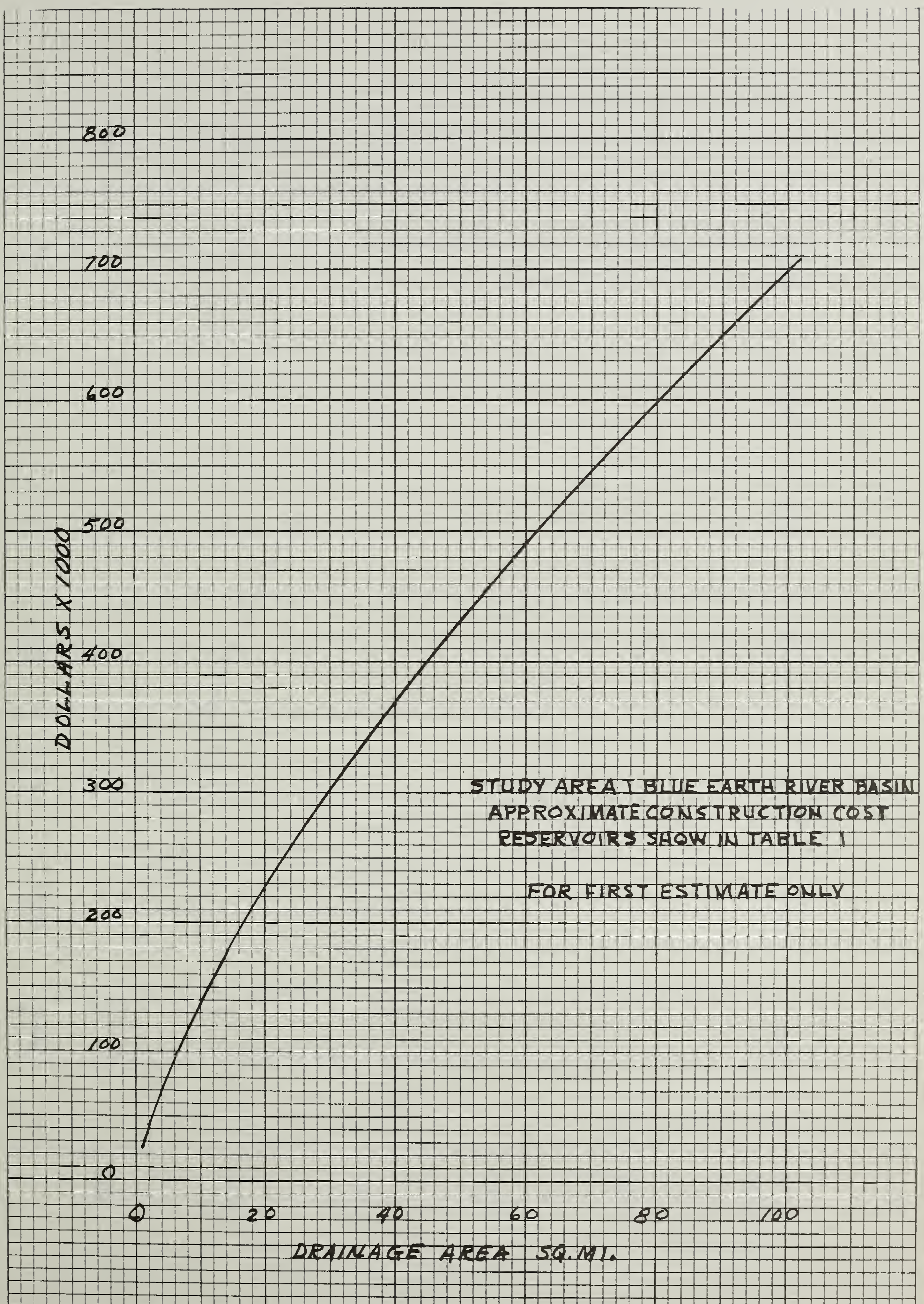
Site No.	Drainage Area (Sq. Mi.)	Storage Available (Ac. Ft.)	(Inches)
8e-03-11	0.7	30	0.9
8e-03-12	1.6	40	0.5
8e-09-1	86.4	1900	0.4
8e-10-1	30.8	1100	0.7
8e-10-2	78.4	2700	0.7
8e-16-1	45.2	2410	1.0
8e-16-10	5.0	60	0.2
8e-17-1	46.0	2190	0.9
8e-17-2	28.6	1060	0.7
8e-17-4	190.0	9930	1.0
8e-17-13	3.2	50	0.3
8e-17-14	2.0	180	1.7
8e-18-3	83.5	6400	1.4
8e-18-11	1.8	92	0.1
8e-18-12	0.1	0	0
8e-18-13	1.7	70	0.8
8e1-01-7	17.2	1700	1.8
8e1-01-10	2.9	290	1.9
8e1-01-11	1.6	170	1.8
8e1-01-12	2.7	200	1.5
8e1-01-15	1.7	140	1.5
8e1-02-4	25.5	1950	1.4
8e1-02-5	32.2	3000	1.7
8e1-05-10	5.3	420	1.5
8e1-07-1	16.3	270	0.3
8e1-07-2	35.0	980	0.5
8e1-07-5	115.1	7910	1.3

TABLE 2 (cont.)

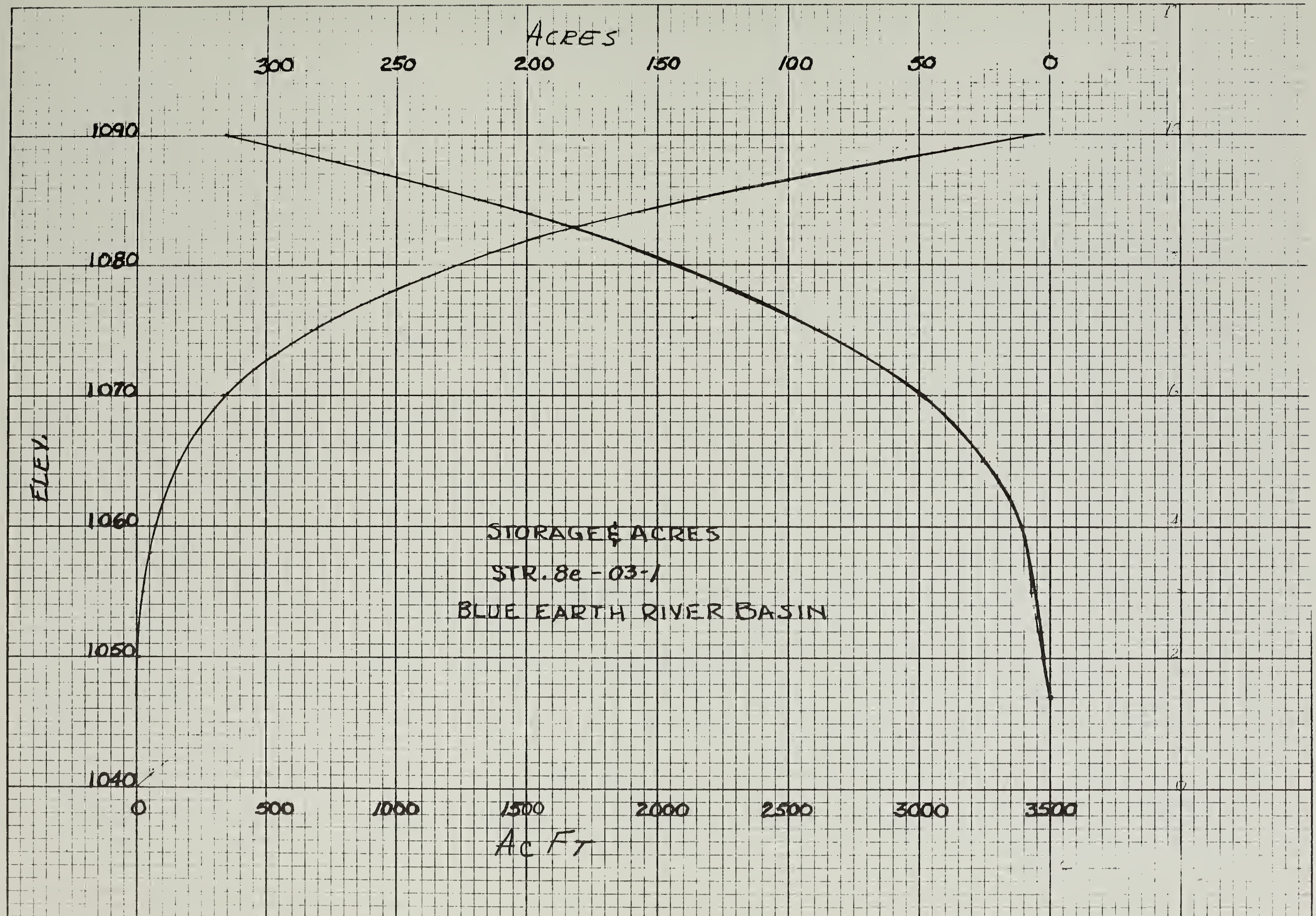
OTHER SITES EVALUATED

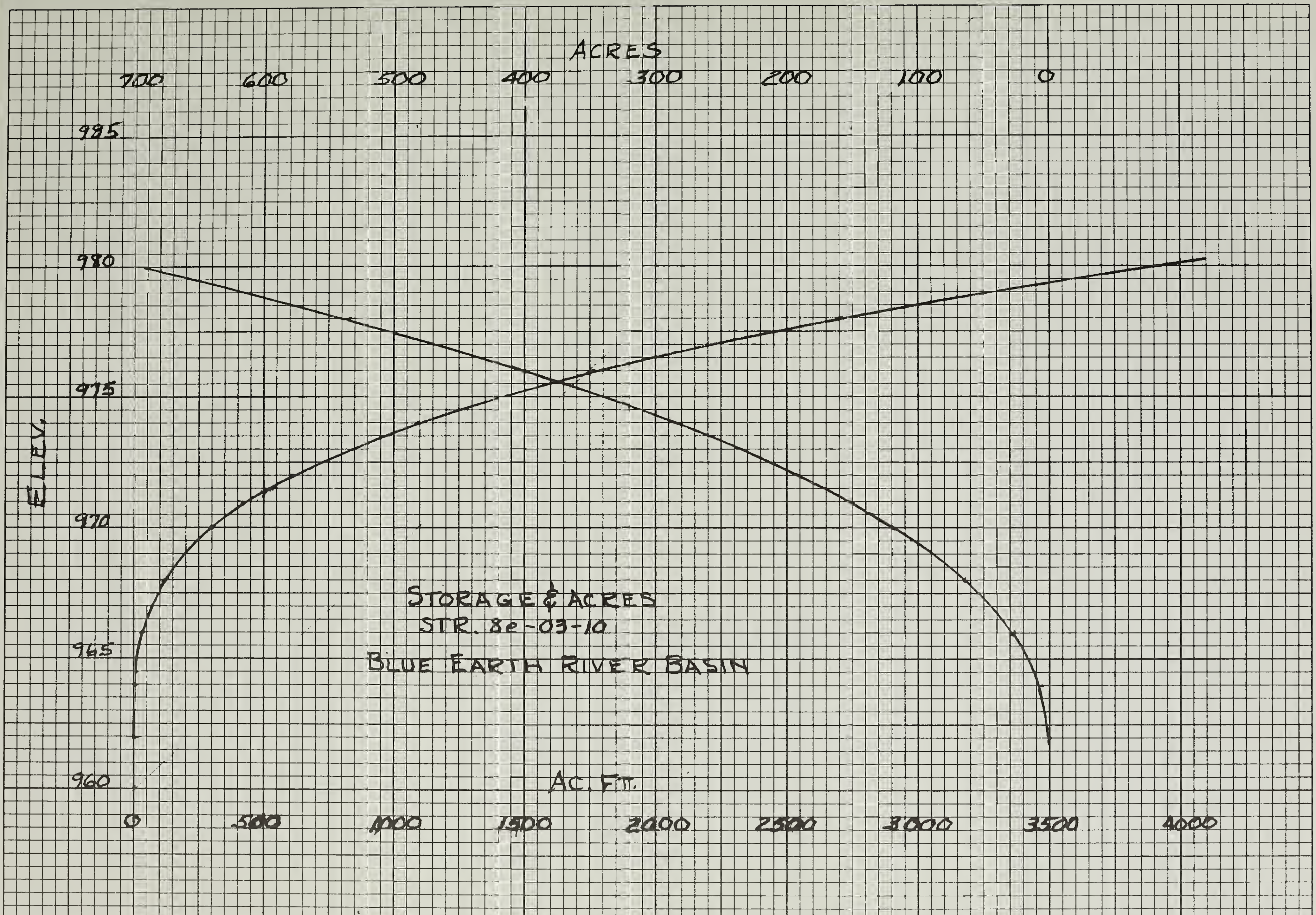
STUDY AREA 1 - BLUE EARTH RIVER BASIN

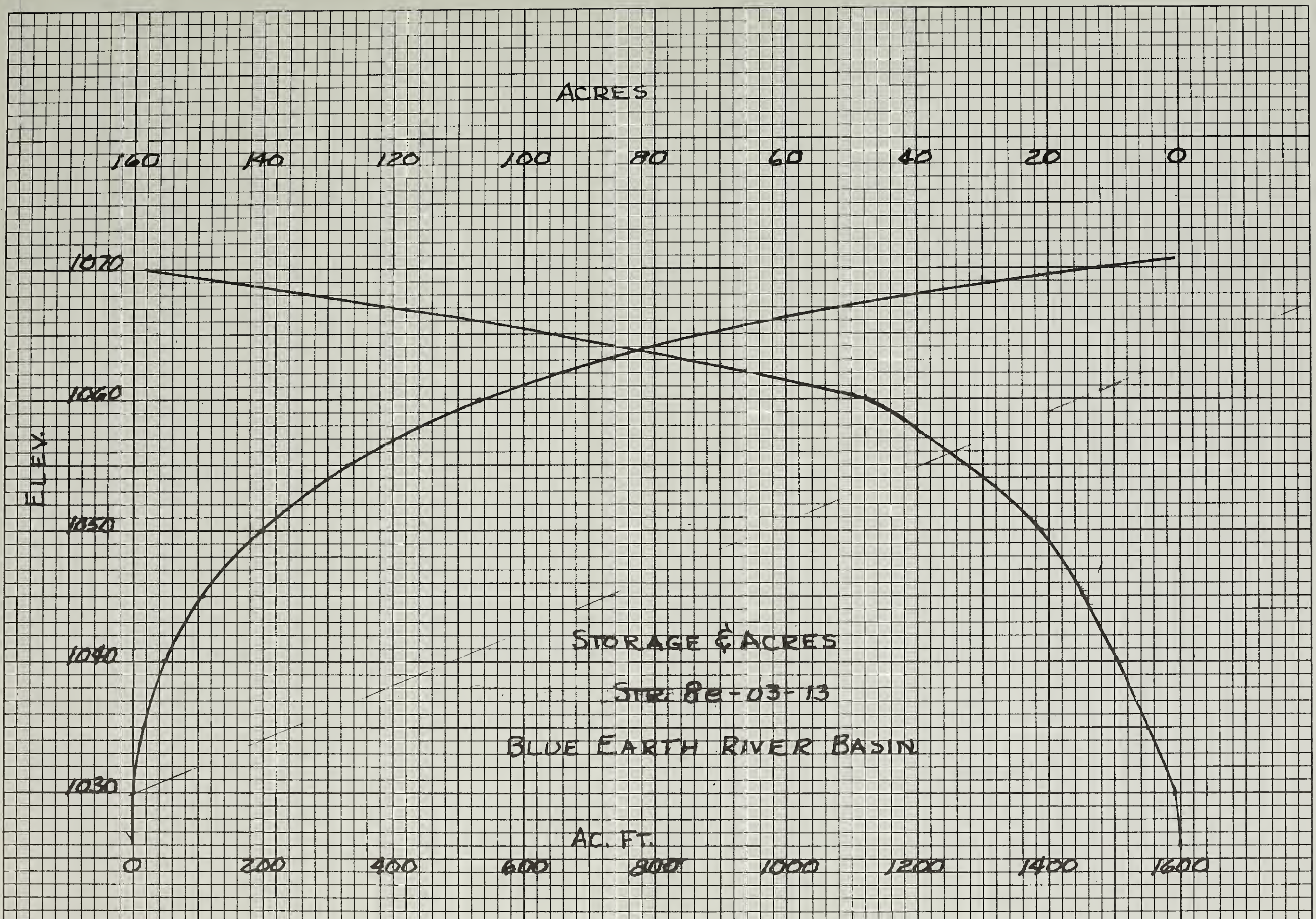
Site No.	Drainage Area (Sq. Mi.)	Storage Available (Ac. Ft.)	Storage Available (Inches)
8e1-08-1	19.6	1730	1.7
8e1-13-1	19.8	1480	1.4
8e2-01-2	10.2	440	0.8
8e2-01-13	1.5	10	0.1
8e2-01-16	3.7	350	1.8
8e2-06-3	41.8	3600	1.6
8e2-06-6	129.4	3030	0.4
8e2-06-13	3.0	50	0.3
8e2-06-14	2.8	40	0.3
8e2-06-15	2.4	60	0.5
8e2-06-16	1.6	60	0.7
8e2-07-2	79.1	2420	0.6
8e2-07-4	128.3	4330	0.6
8e2-07-13	.4	30	1.5
8e2-09-11	3.0	130	0.8
8e2-11-1	50.0	1930	0.7



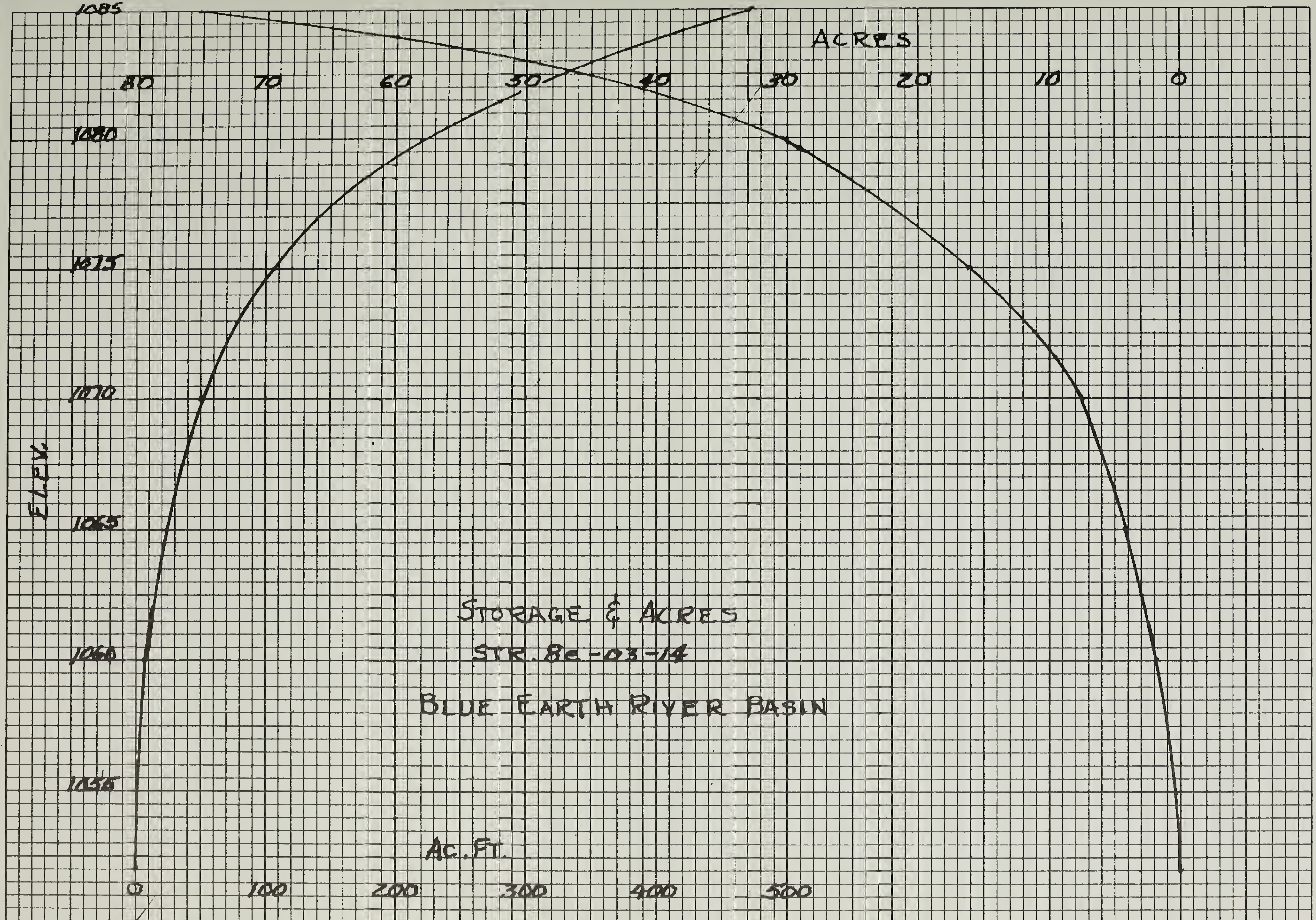
800
700
600
500
400
300
200
100
0
DOLLARS X 1000
STUDY AREA I BLUE EARTH RIVER BASIN
APPROXIMATE CONSTRUCTION COST
RESERVOIRS SHOW IN TABLE 1
FOR FIRST ESTIMATE ONLY
0
20
40
60
80
100
DRAINAGE AREA SQ. MI.

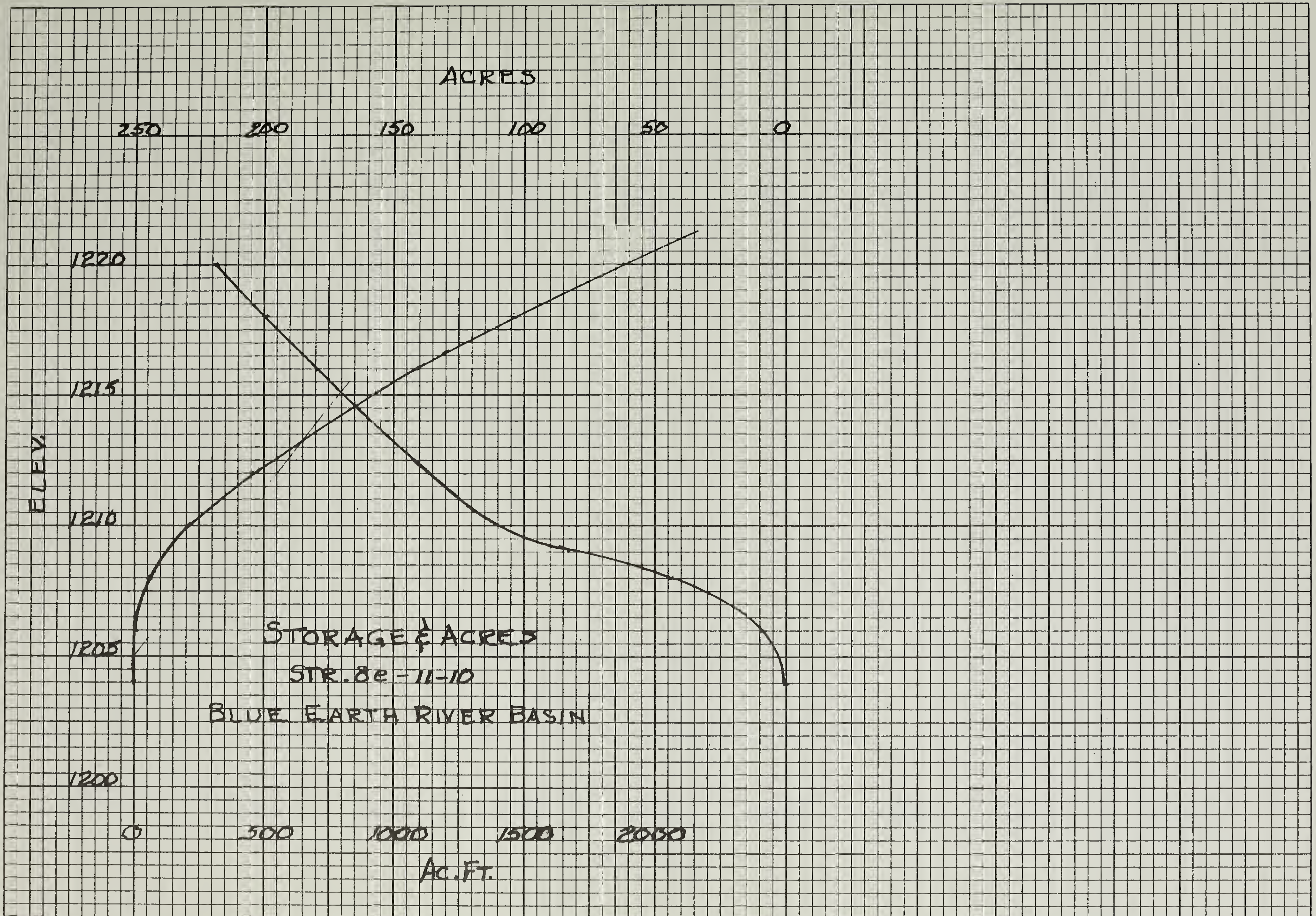

ACRES
300
250
200
150
100
50
0
1090
1080
1070
1060
1050
1040
ELEV.
STORAGE & ACRES
STR. 8e - 03-1
BLUE EARTH RIVER BASIN
0
500
1000
1500
2000
2500
3000
3500
AC FT


ACRES
700 600 500 400 300 200 100 0
985
980
975
970
965
960
ELEV.
STORAGE & ACRES
STR. 8e-03-10
BLUE EARTH RIVER BASIN
AC. FT.
0 500 1000 1500 2000 2500 3000 3500 4000

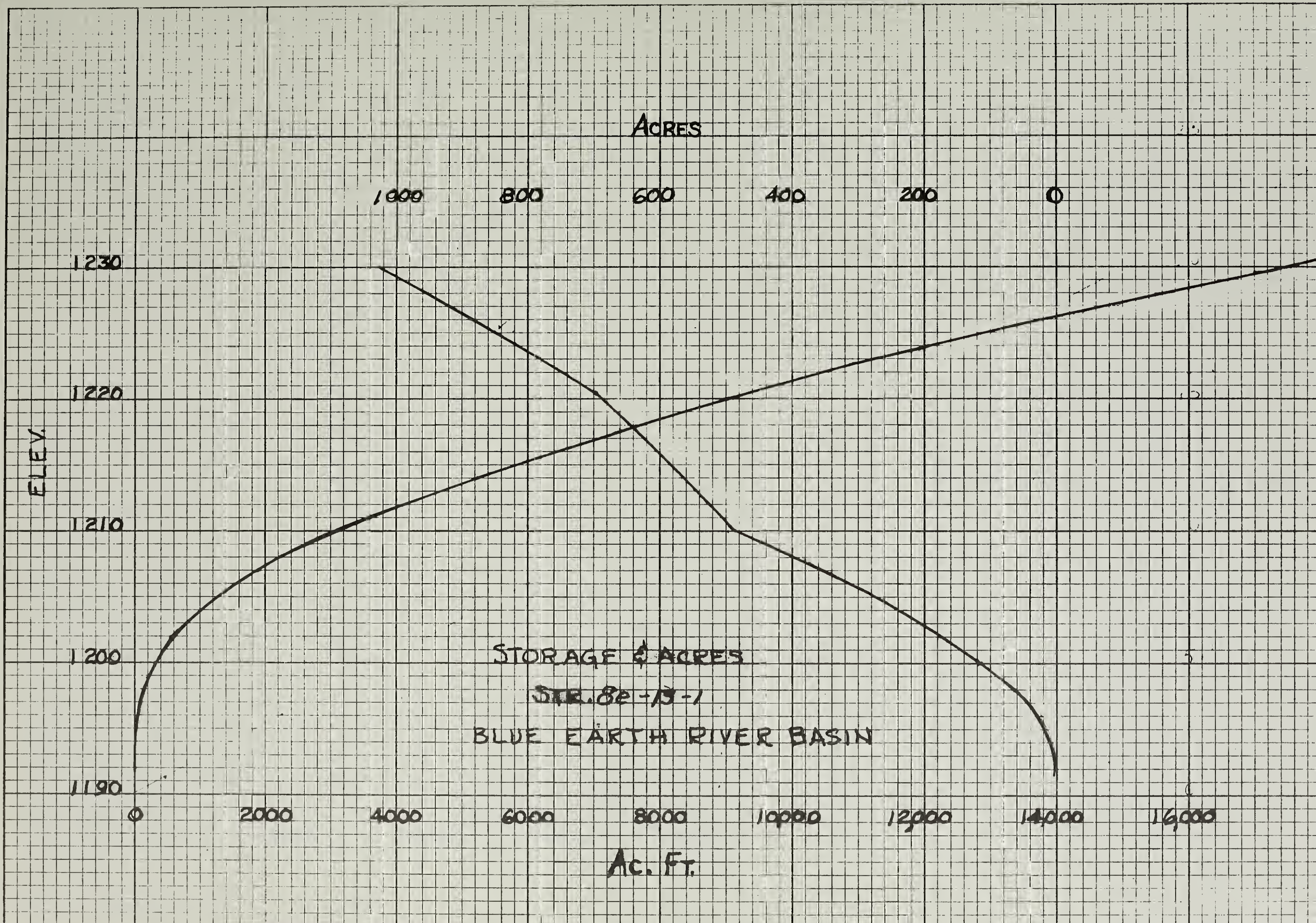


ACRES
160
140
120
100
80
60
40
20
0
1070
1060
ELEV.
1050
1040
1030
STORAGE & ACRES
STR. 8e-03-13
BLUE EARTH RIVER BASIN
AC. FT.
0
200
400
600
800
1000
1200
1400
1600

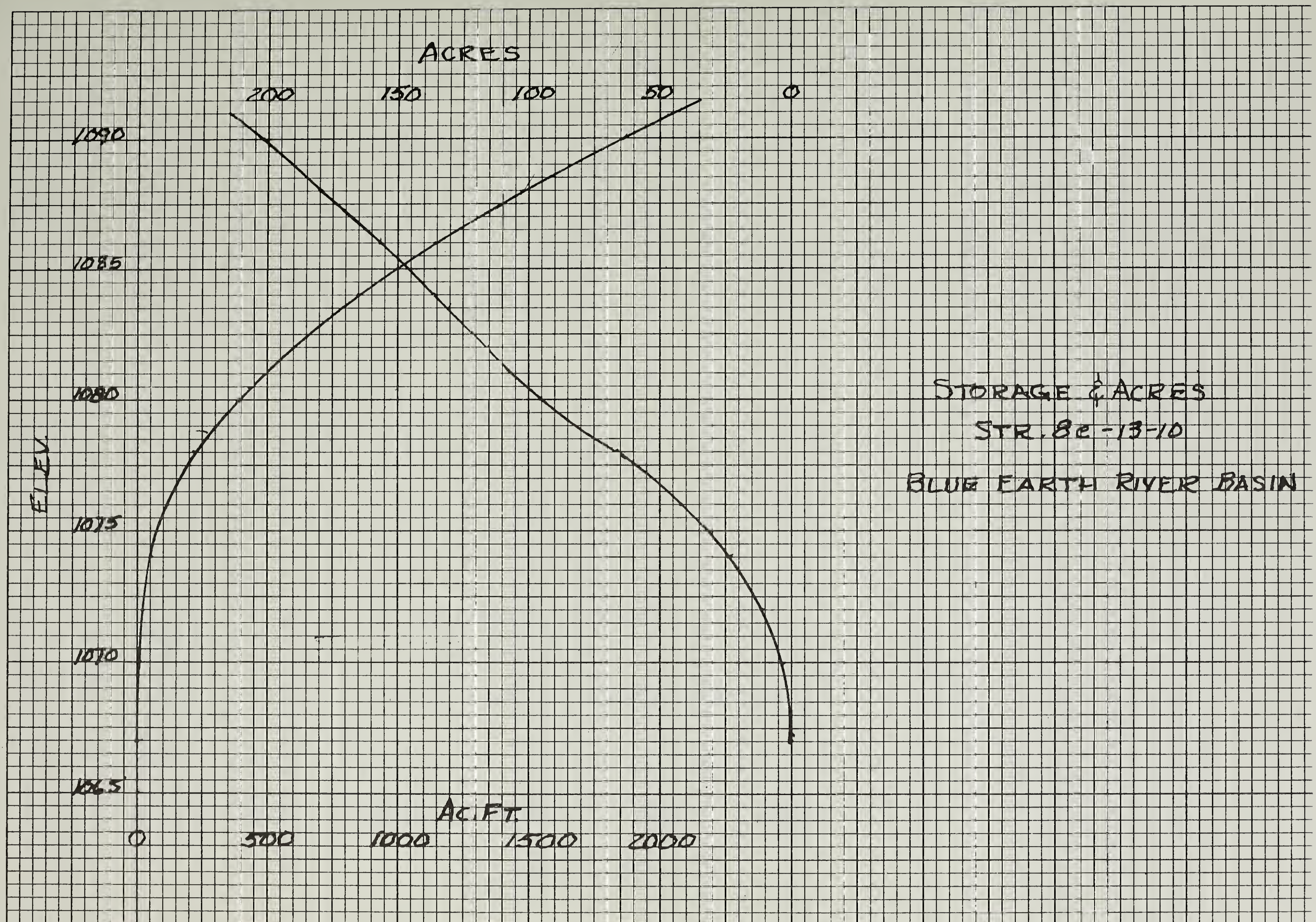

ACRES
80
70
60
50
40
30
20
10
0
1085
1080
1075
1070
1065
1060
1055
ELEV.
STORAGE & ACRES
STR. 8e-03-14
BLUE EARTH RIVER BASIN
AC. FT.
0
100
200
300
400
500



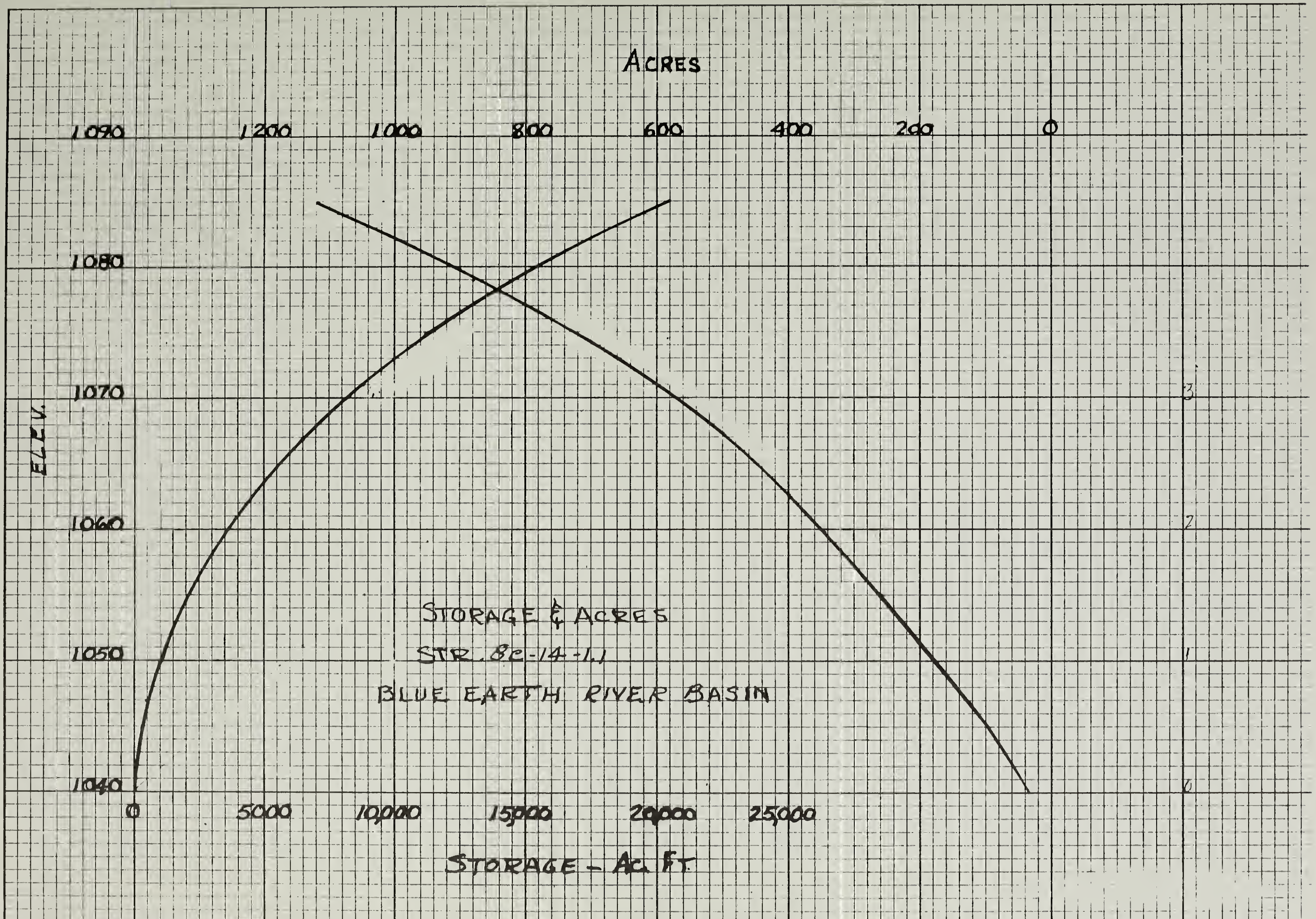
ACRES
250
200
150
100
50
0
ELEV.
1220
1215
1210
1205
1200
STORAGE & ACRES
STR. 8e-11-10
BLUE EARTH RIVER BASIN
0
500
1000
1500
2000
AC. FT.



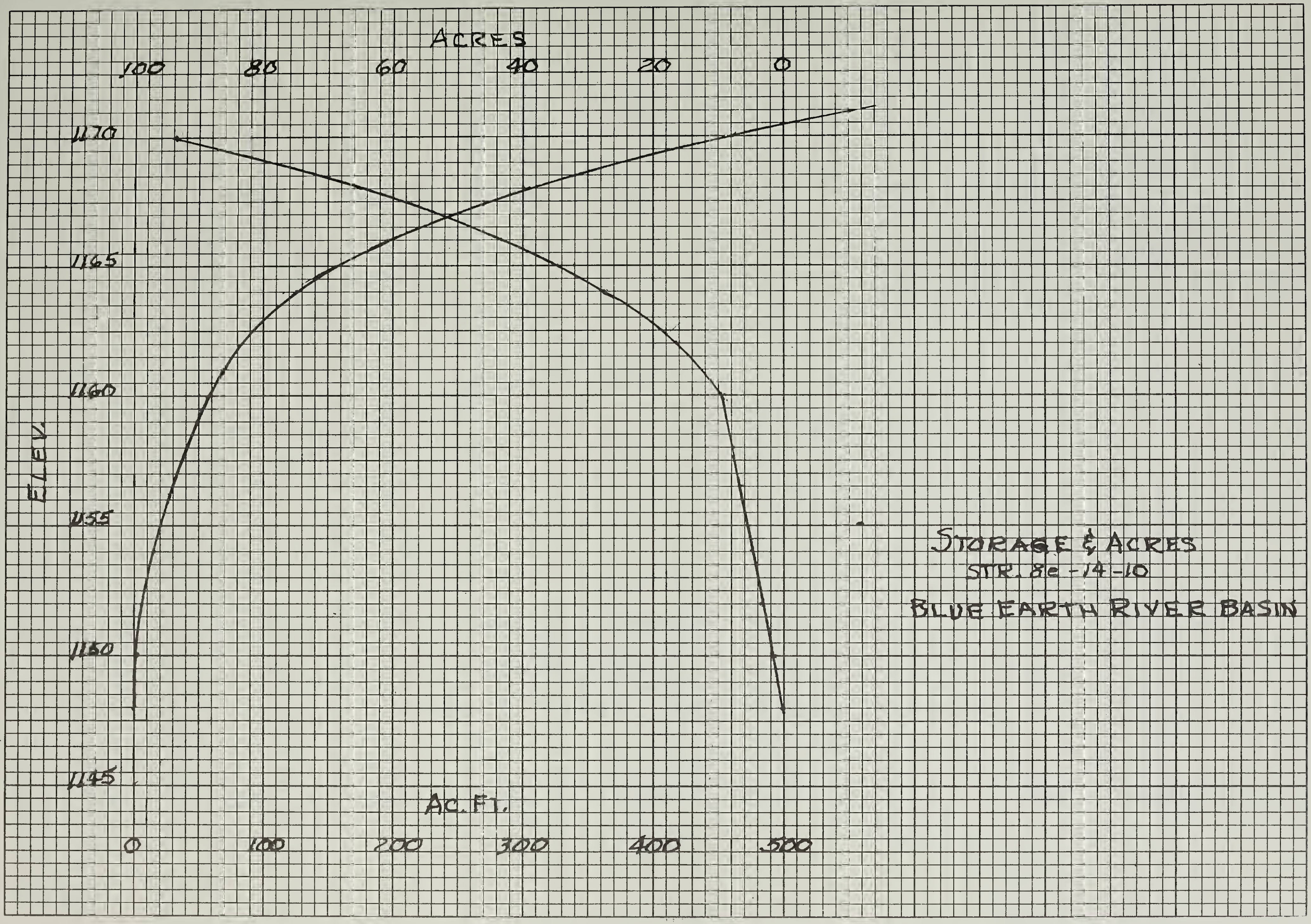
ACRES
1000
800
600
400
200
0
ELEV.
1230
1220
1210
1200
1190
STORAGE & ACRES
STR. 8e-13-1
BLUE EARTH RIVER BASIN
0
2000
4000
6000
8000
10000
12000
14000
16,000
AC. FT.



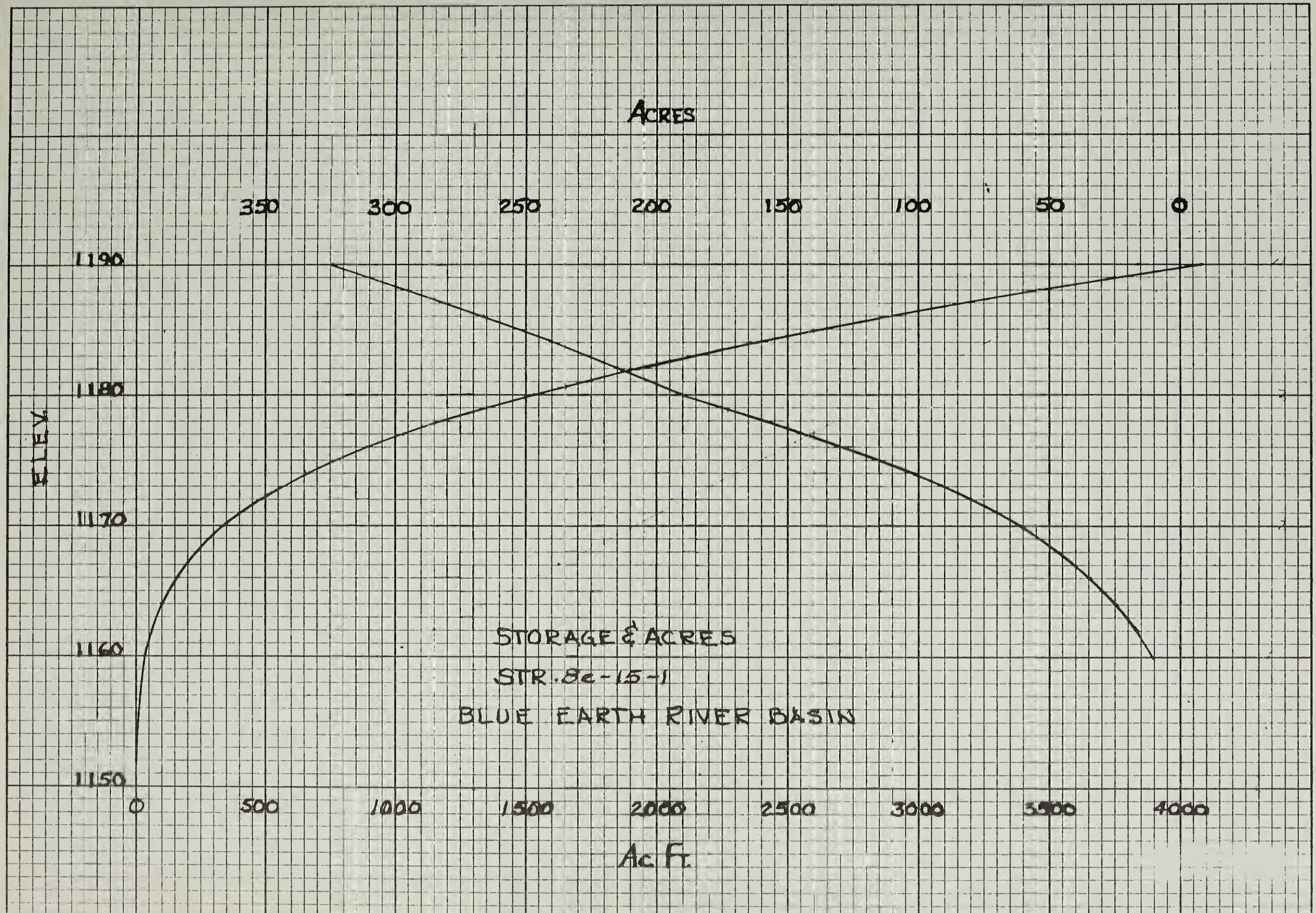
STORAGE & ACRES
STR. 8e-13-10
BLUE EARTH RIVER BASIN
ACRES
200
150
100
50
0
ELEV.
1090
1085
1080
1075
1070
1065
AC. FT.
0
500
1000
1500
2000

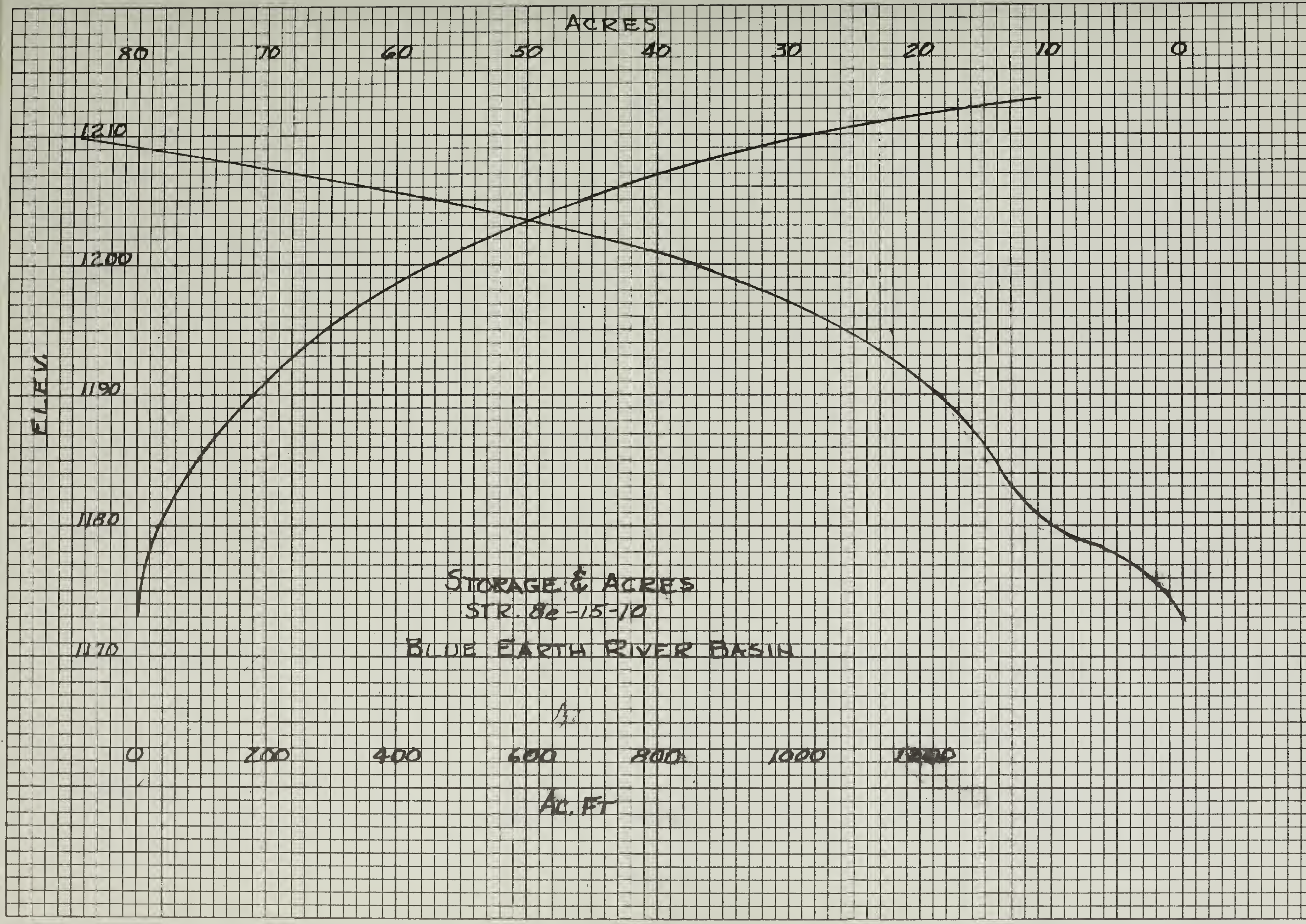


ACRES
1090
1200
1000
800
600
400
200
0
1080
1070
ELEV.
1060
1050
1040
3
2
1
0
STORAGE & ACRES
STR. 8c-14-1.1
BLUE EARTH RIVER BASIN
0
5000
10,000
15,000
20,000
25,000
STORAGE - AC. FT.

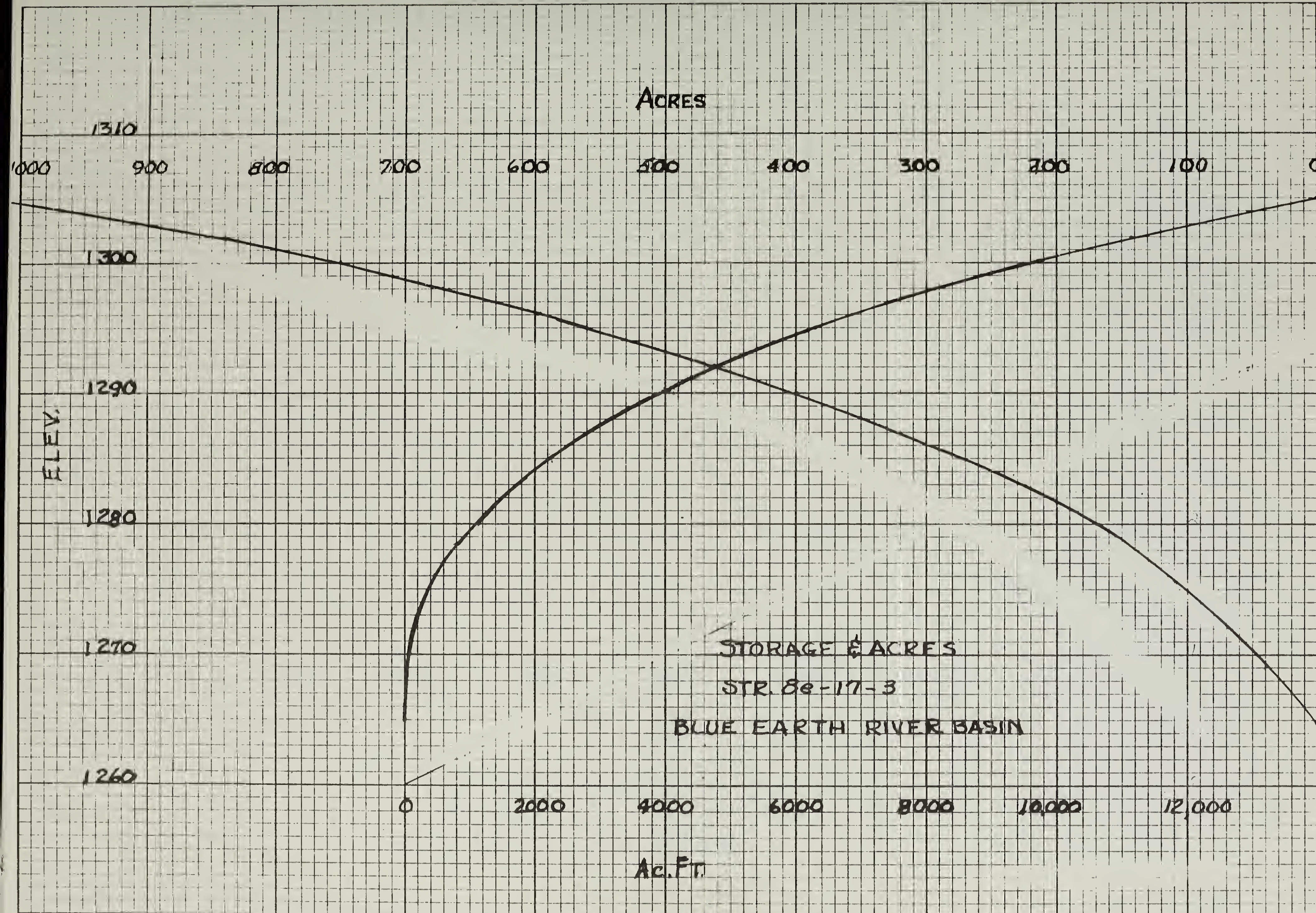


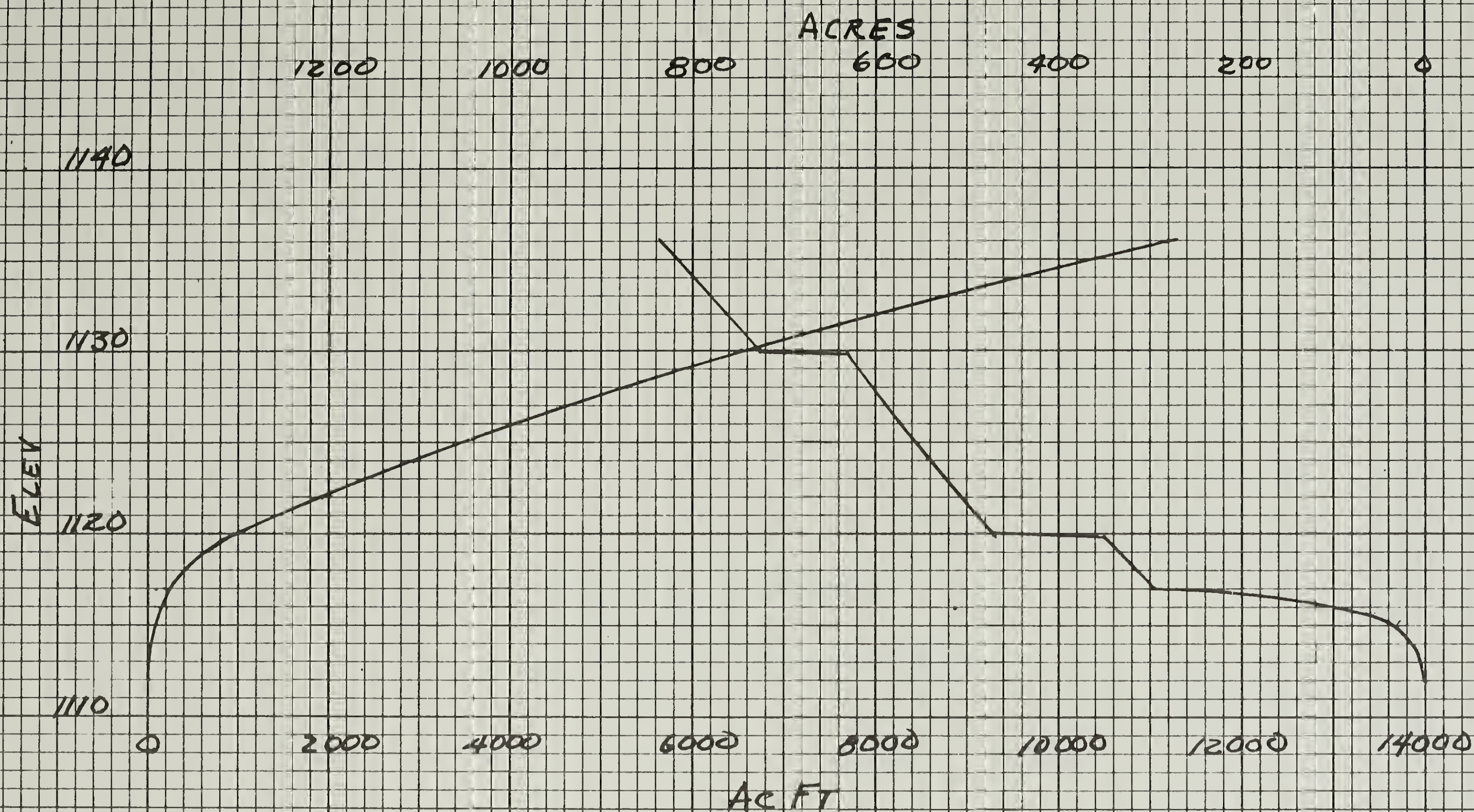
STORAGE & ACRES
STR. 8e-14-10
BLUE EARTH RIVER BASIN
ACRES
100
80
60
40
20
0
ELEV.
1170
1165
1160
1155
1150
1145
AC. FT.
0
100
200
300
400
500


ACRES
350
300
250
200
150
100
50
0
1190
1180
ELEV.
1170
1160
1150
STORAGE & ACRES
STR. 8c-15-1
BLUE EARTH RIVER BASIN
0
500
1000
1500
2000
2500
3000
3500
4000
Ac. Ft.



ACRES
80
70
60
50
40
30
20
10
0
ELEV.
1210
1200
1190
1180
1170
STORAGE & ACRES
STR. 8e-15-10
BLUE EARTH RIVER BASIN
0
200
400
600
800
1000
1200
AC. FT

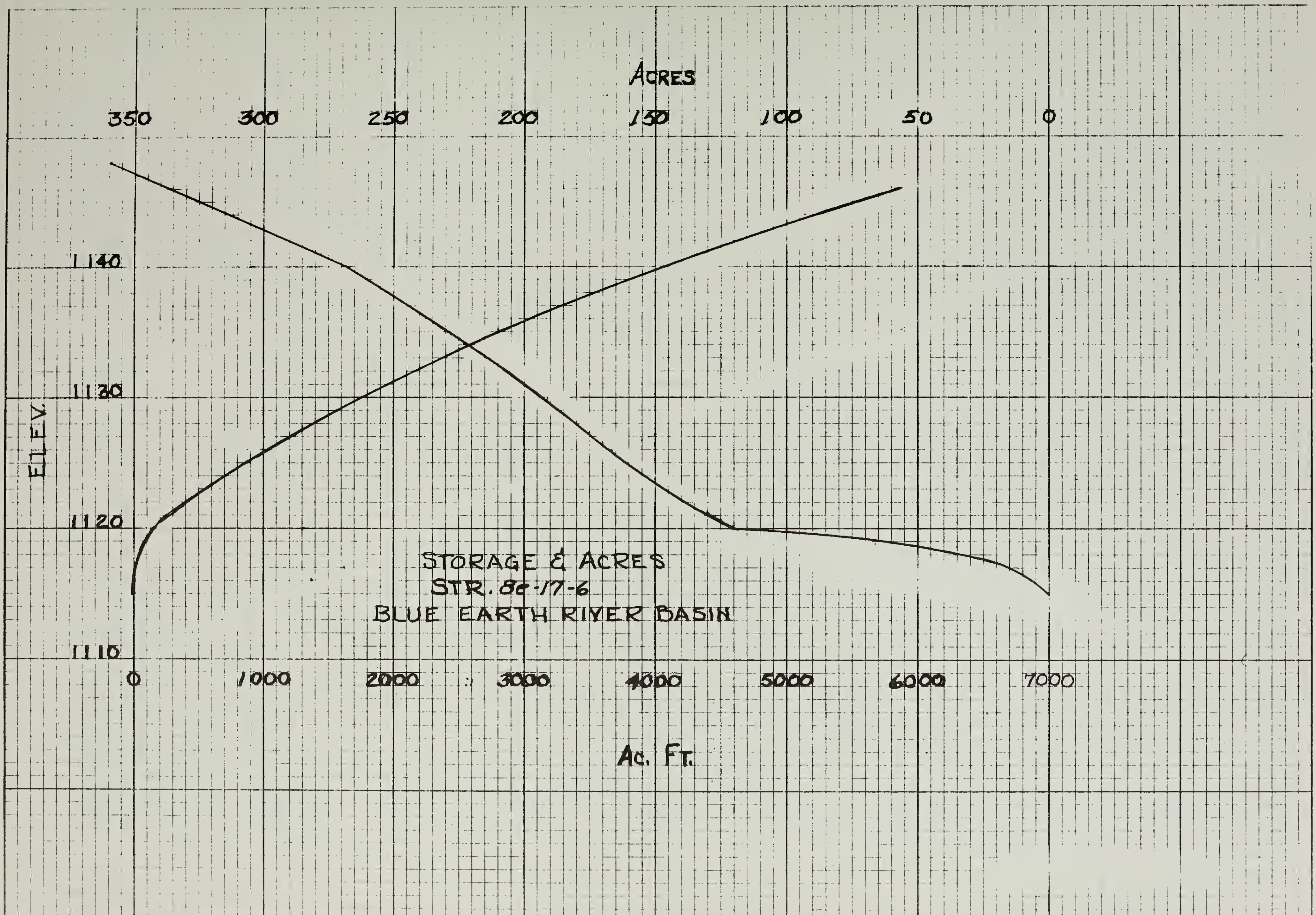

ACRES
1000
900
800
700
600
500
400
300
200
100
0
1310
1300
1290
1280
1270
1260
ELEV.
STORAGE & ACRES
STR. 8e-17-3
BLUE EARTH RIVER BASIN
0
2000
4000
6000
8000
10,000
12,000
Ac. Ft.



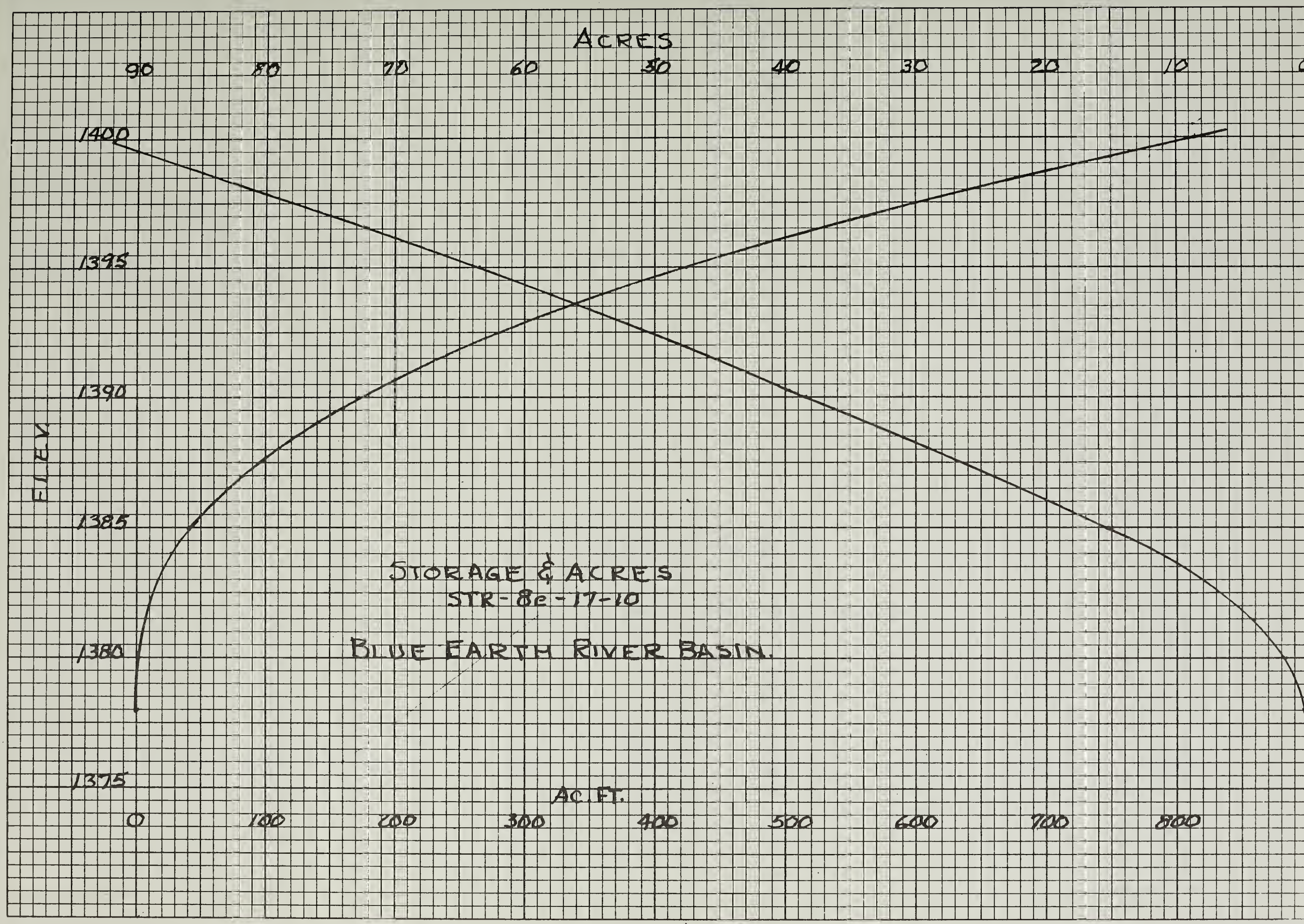
STORAGE & ACRES

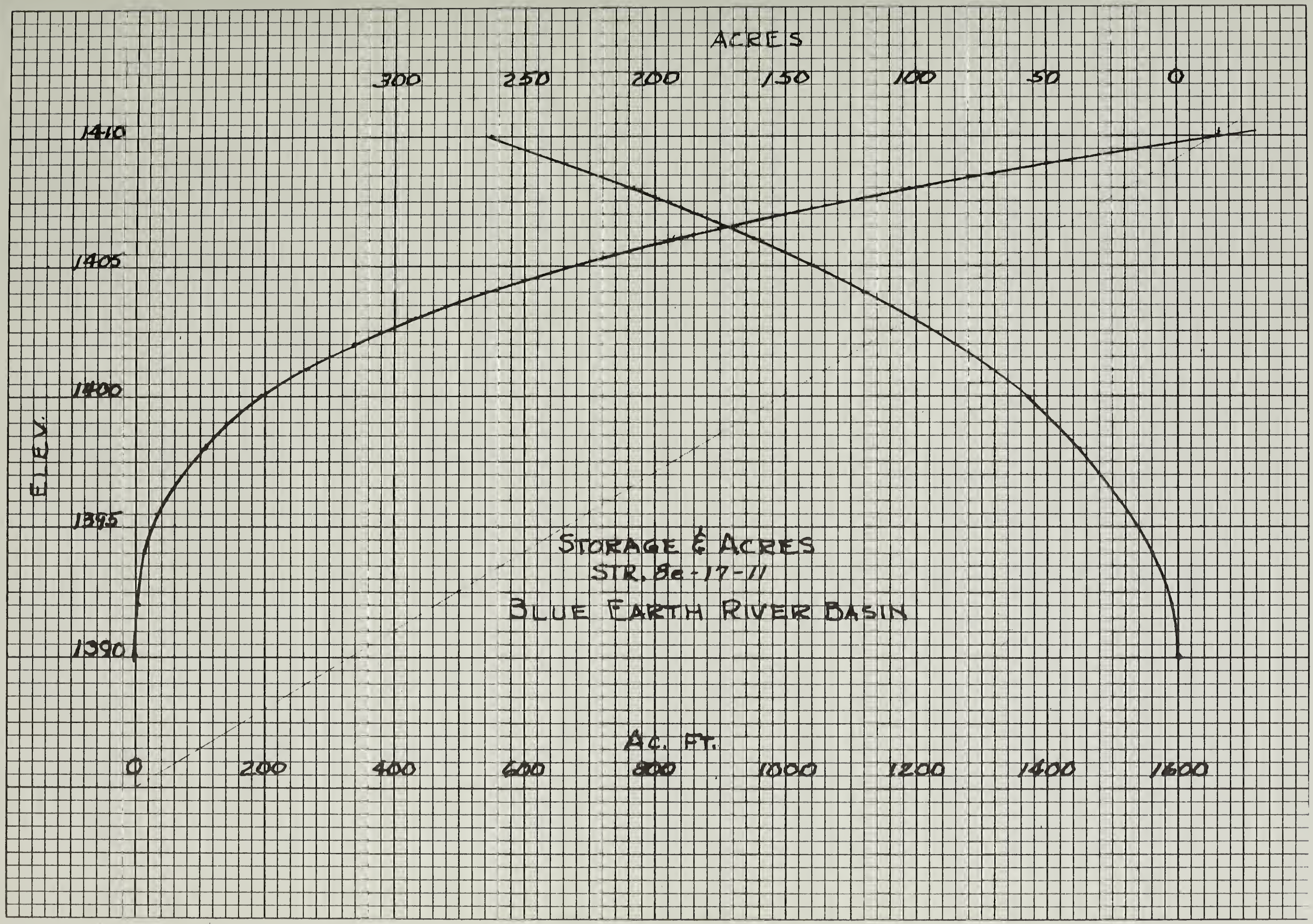
STR 8e-17-5

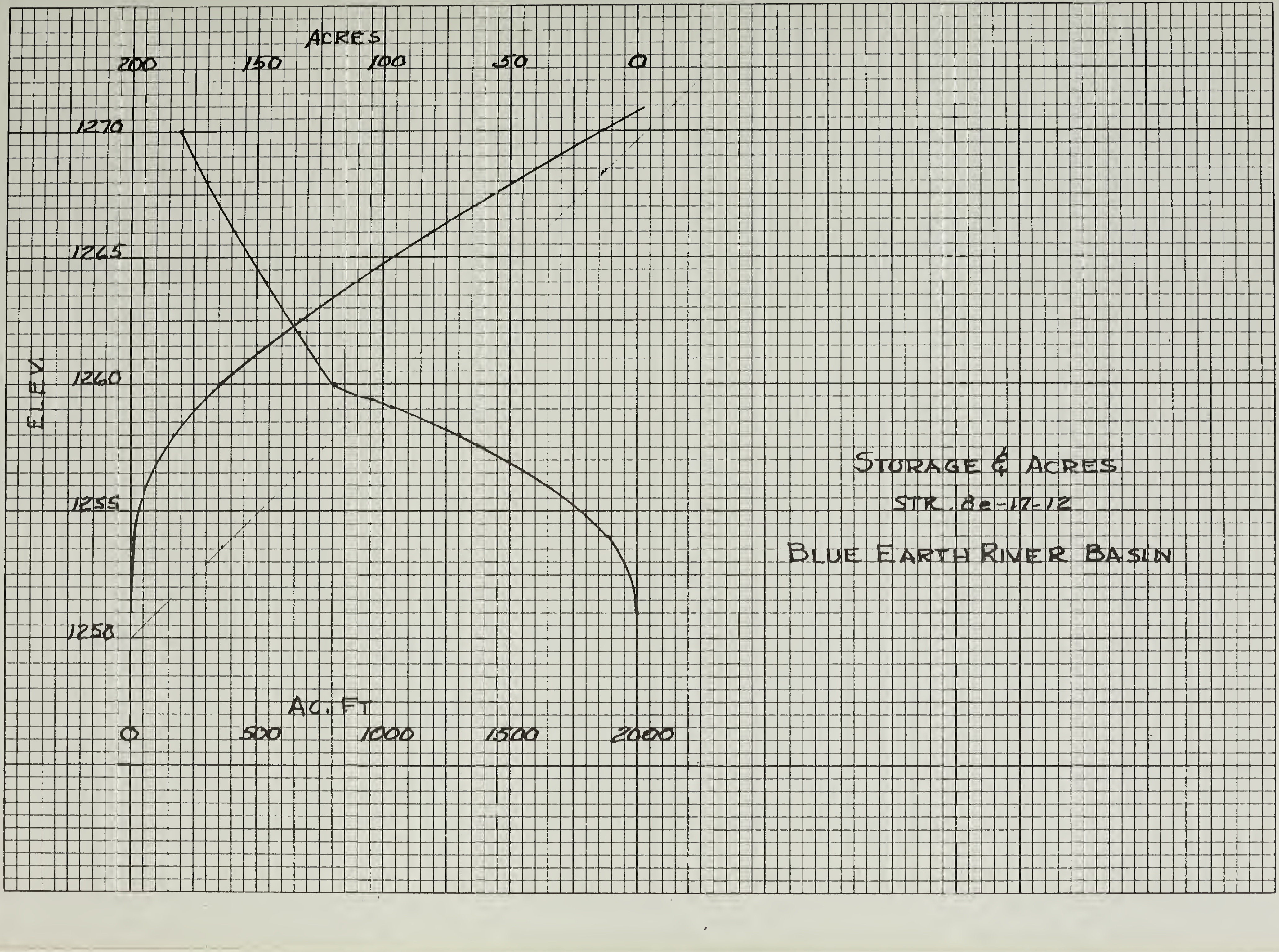
BLUE EARTH RIVER BASIN



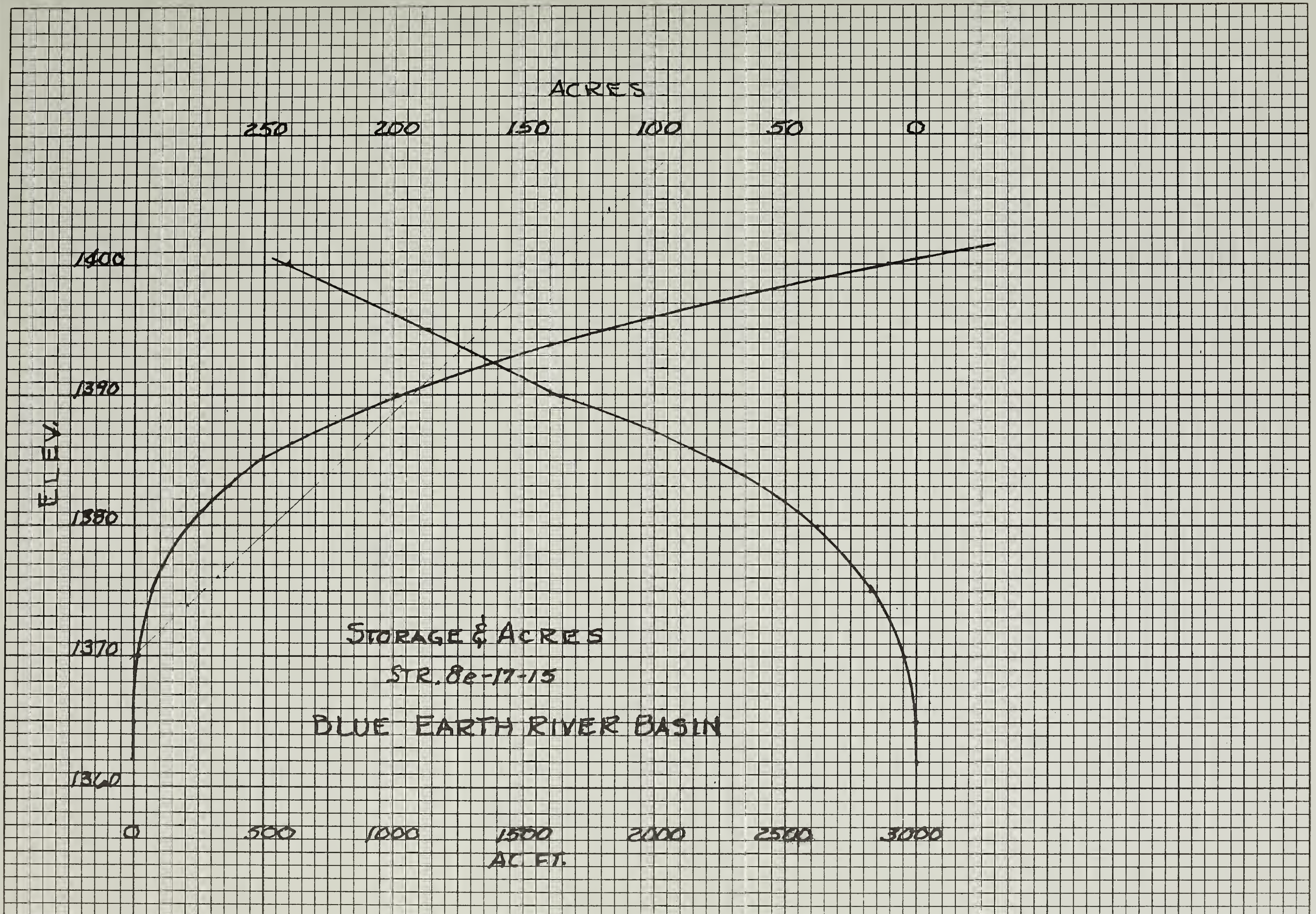
ACRES
350
300
250
200
150
100
50
0
ELEV.
1140
1130
1120
1110
STORAGE & ACRES
STR. 8e-17-6
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
7000
AC. FT.


ACRES
90
80
70
60
50
40
30
20
10
0
ELEV
1400
1395
1390
1385
1380
1375
STORAGE & ACRES
STR-8e-17-10
BLUE EARTH RIVER BASIN.
AC. FT.
0
100
200
300
400
500
600
700
800

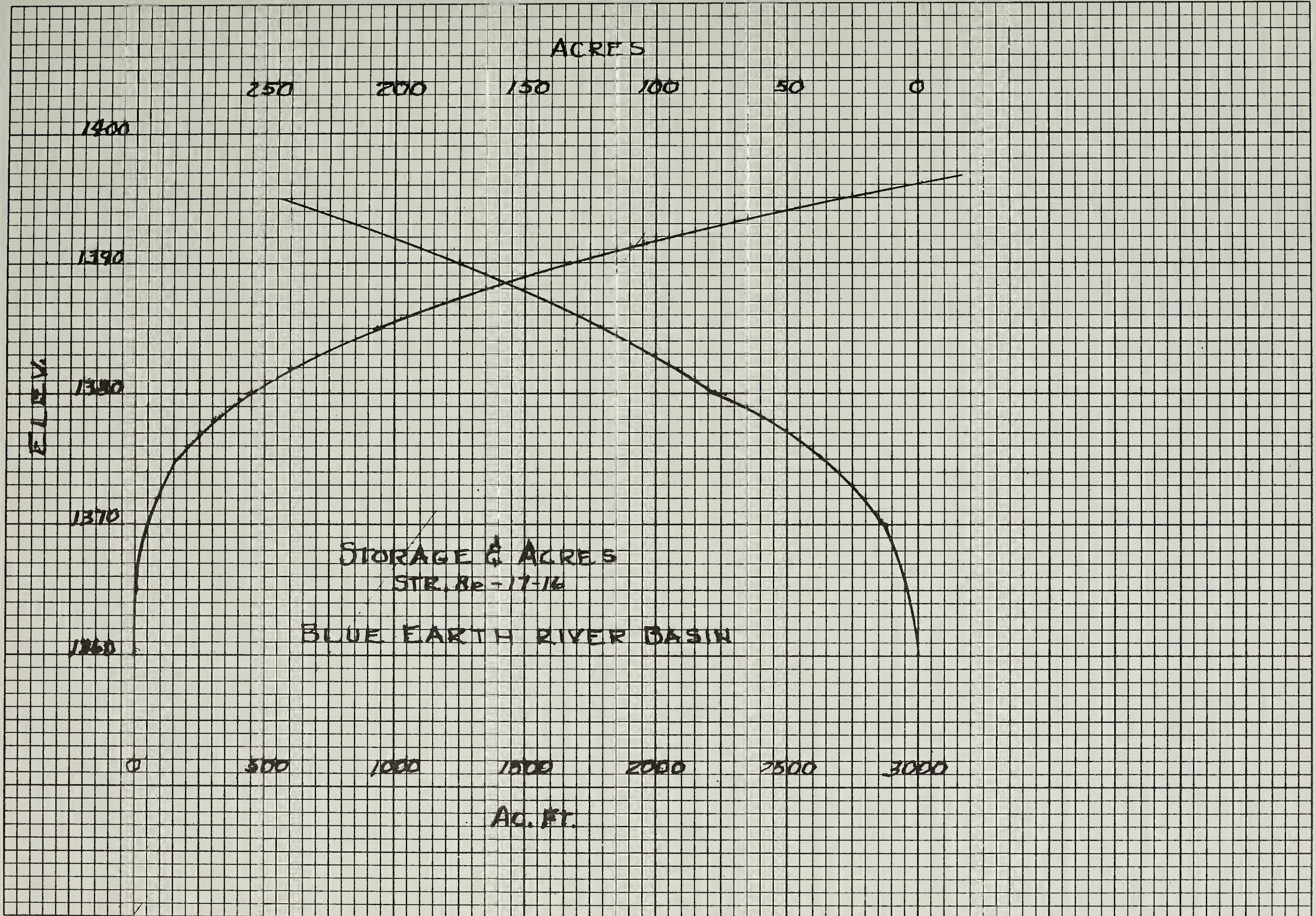

ACRES
300
250
200
150
100
50
0
1410
1405
1400
1395
1390
ELEV.
STORAGE & ACRES
STR. 8e-17-11
BLUE EARTH RIVER BASIN
AC. FT.
0
200
400
600
800
1000
1200
1400
1600



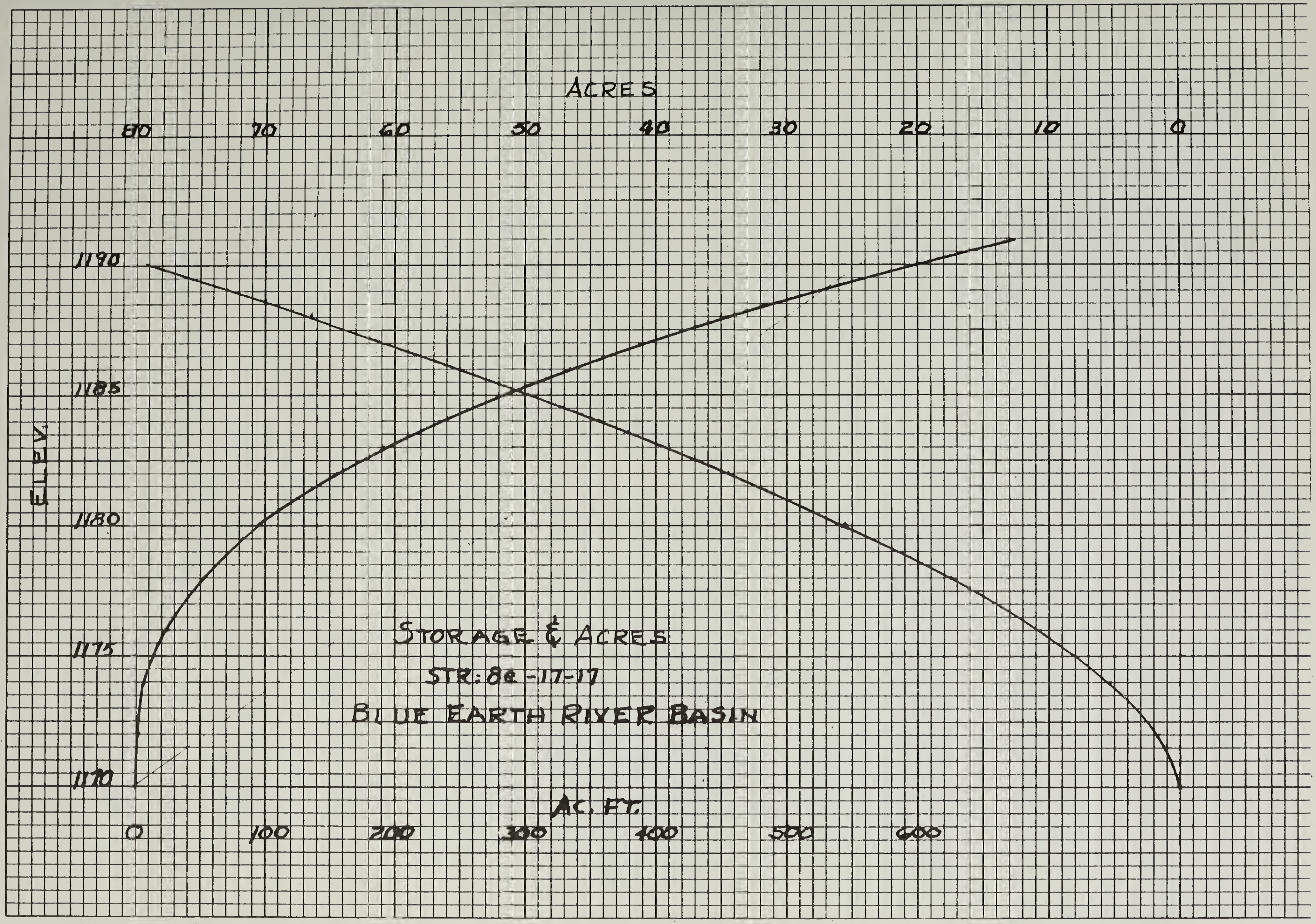
ACRES
200
150
100
50
0
ELEV.
1270
1265
1260
1255
1250
AC. FT
0
500
1000
1500
2000
STORAGE & ACRES
STR. Be-17-12
BLUE EARTH RIVER BASIN

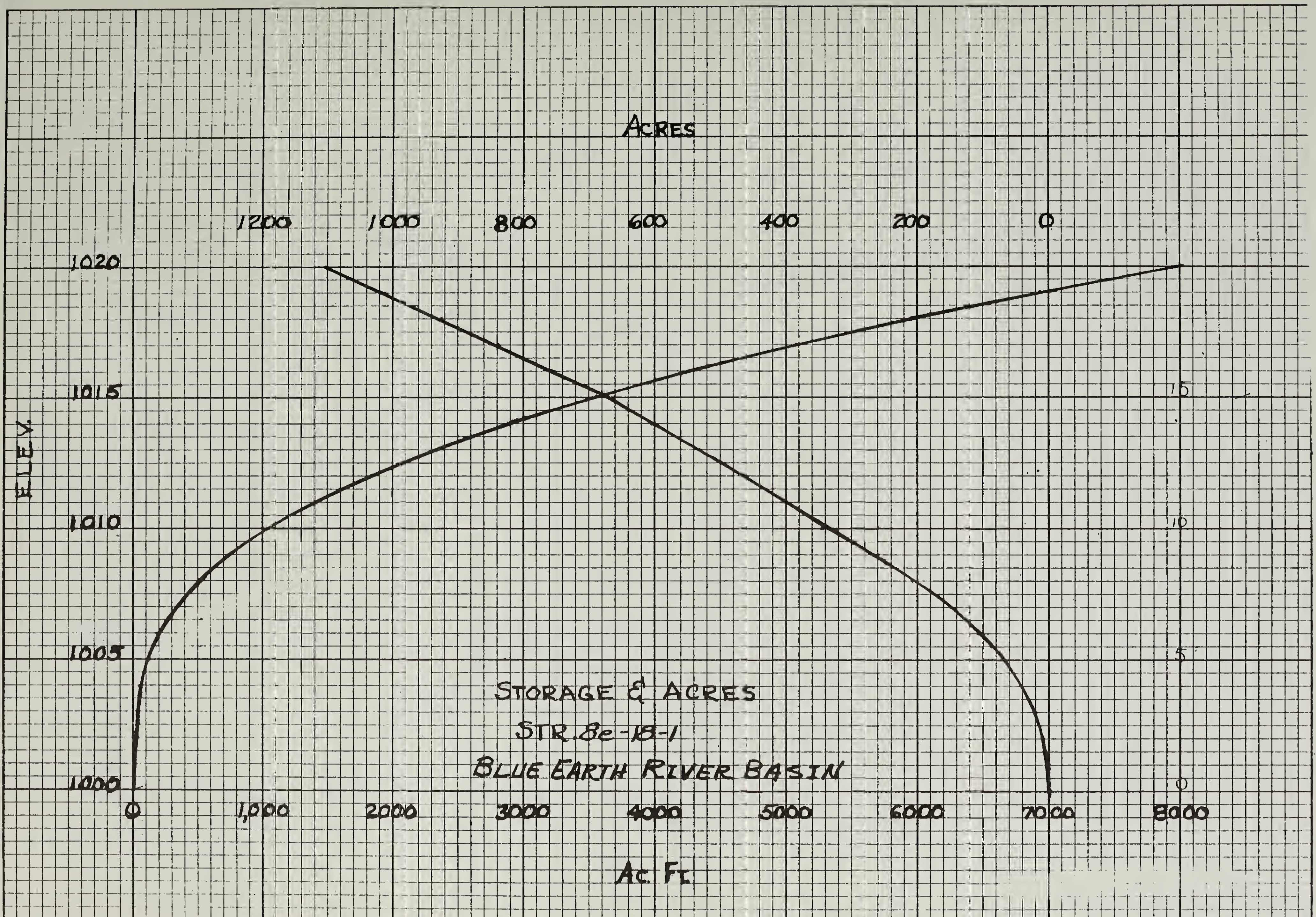


ACRES
250
200
150
100
50
0
ELEV.
1400
1390
1380
1370
1360
STORAGE & ACRES
STR. 8e-17-15
BLUE EARTH RIVER BASIN
0
500
1000
1500
2000
2500
3000
AC. FT.

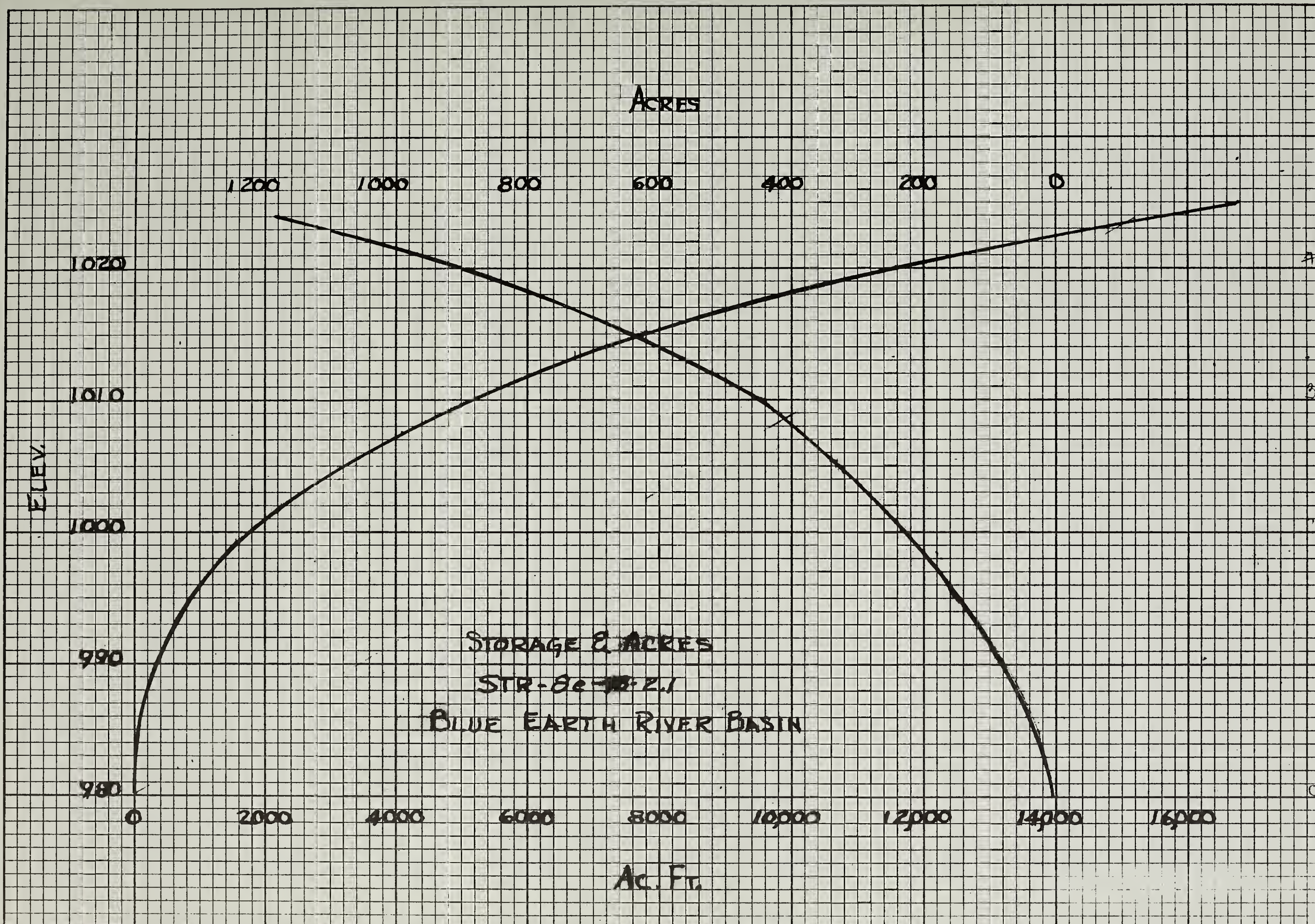


ACRES
250
200
150
100
50
0
1400
1390
1380
1370
1360
ELEV.
STORAGE & ACRES
STR. Be-17-16
BLUE EARTH RIVER BASIN
0
500
1000
1500
2000
2500
3000
AC. FT.

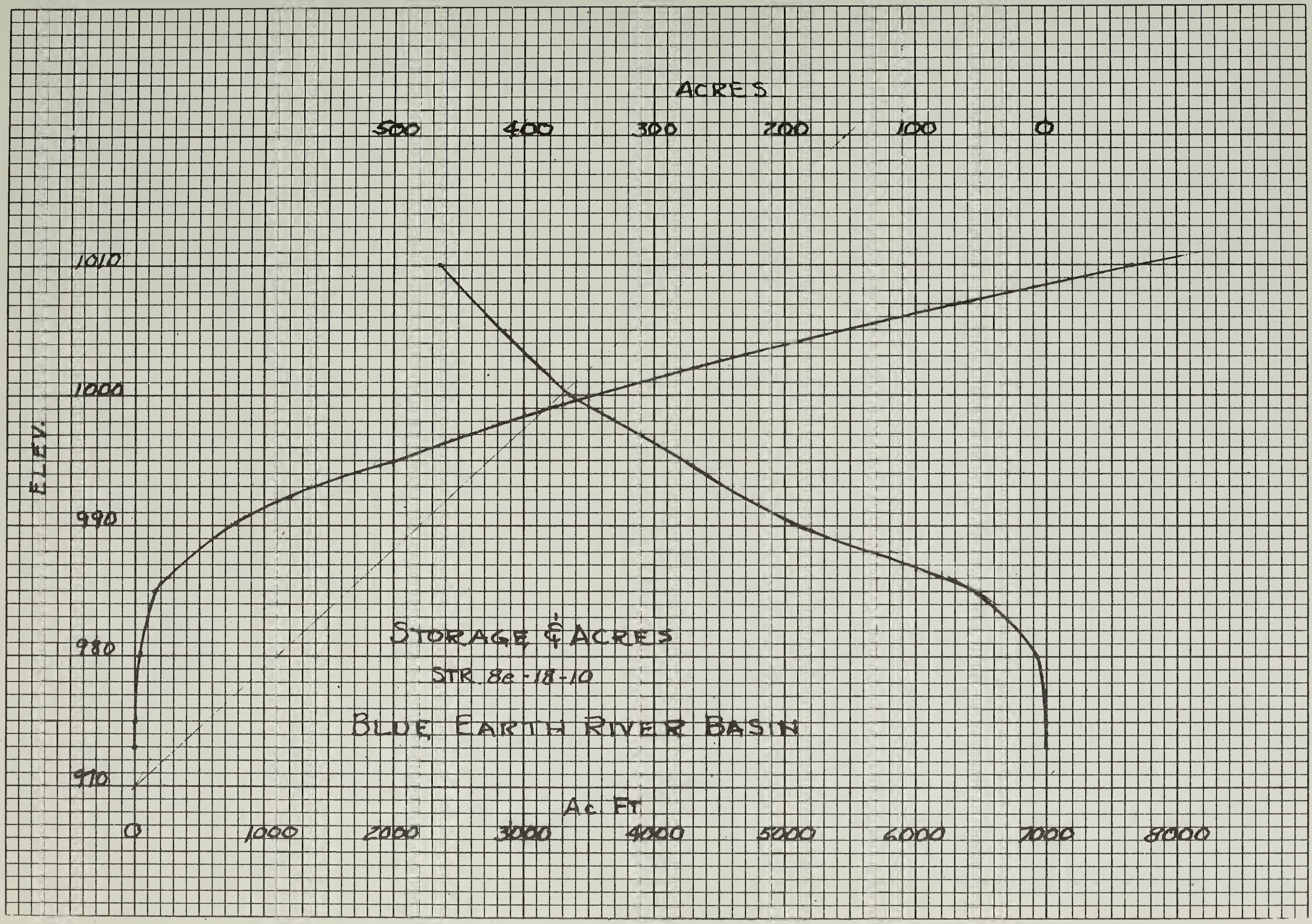

ACRES
80
70
60
50
40
30
20
10
0
ELEV.
1190
1185
1180
1175
1170
STORAGE & ACRES
STR: 82-117-17
BLUE EARTH RIVER BASIN
AC. FT.
0
100
200
300
400
500
600



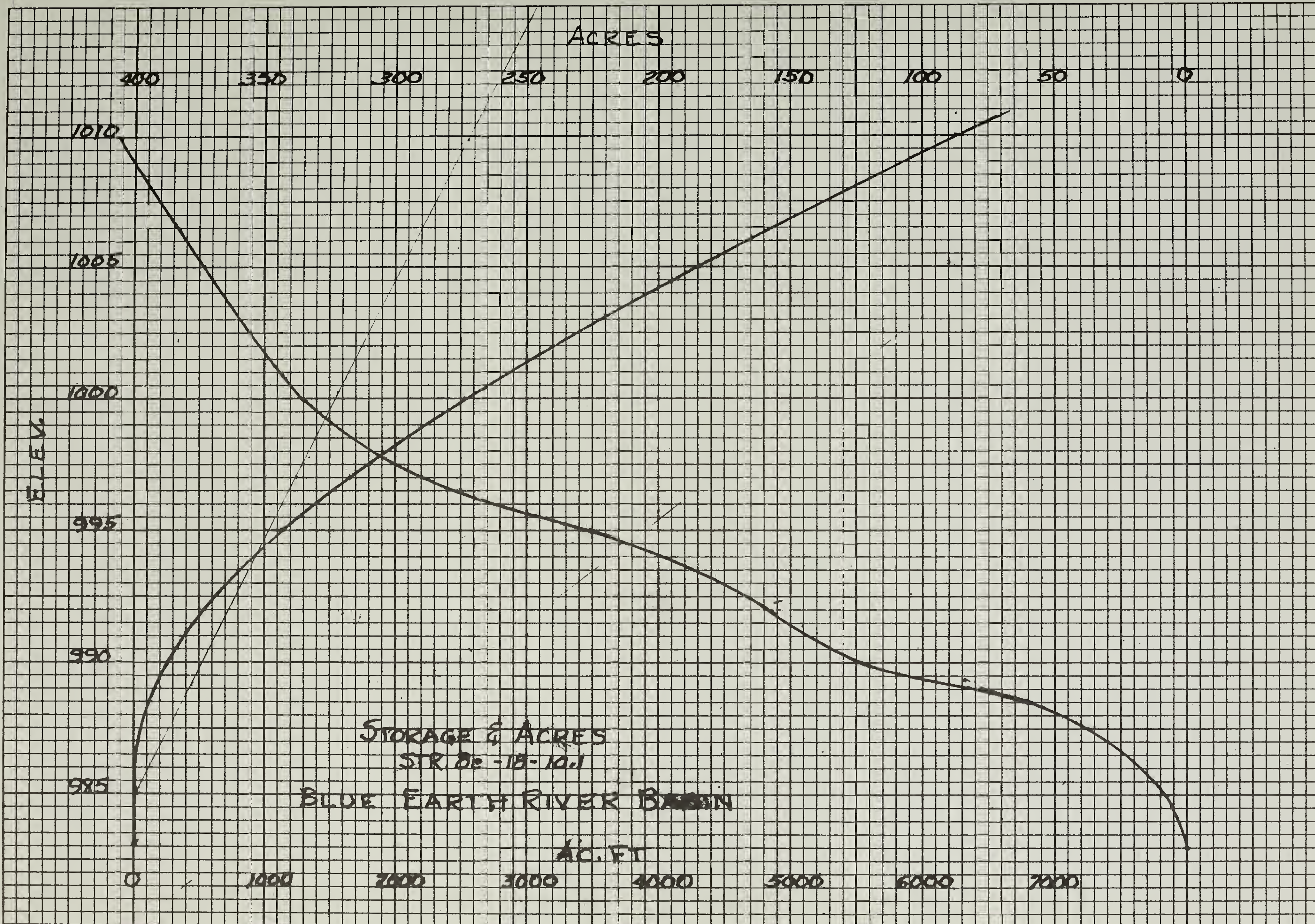
ACRES
1200
1000
800
600
400
200
0
ELEV.
1020
1015
1010
1005
1000
15
10
5
0
STORAGE & ACRES
STR. Be-18-1
BLUE EARTH RIVER BASIN
0
1,000
2000
3000
4000
5000
6000
7000
8000
AC. FT.



Acres
1200
1000
800
600
400
200
0
1020
1010
1000
990
980
Elev.
Storage & Acres
STR-8e-2.1
Blue Earth River Basin
0
2000
4000
6000
8000
10,000
12,000
14,000
16,000
Ac. Ft.



ACRES
500
400
300
200
100
0
ELEV.
1010
1000
990
980
970
STORAGE & ACRES
STR. 8e-18-10
BLUE EARTH RIVER BASIN
Ac. Ft.
0
1000
2000
3000
4000
5000
6000
7000
8000


ACRES
400
350
300
250
200
150
100
50
0
ELEV.
1010
1005
1000
995
990
985
STORAGE & ACRES
STR. 8c-18-10.1
BLUE EARTH RIVER BASIN
AC. FT
0
1000
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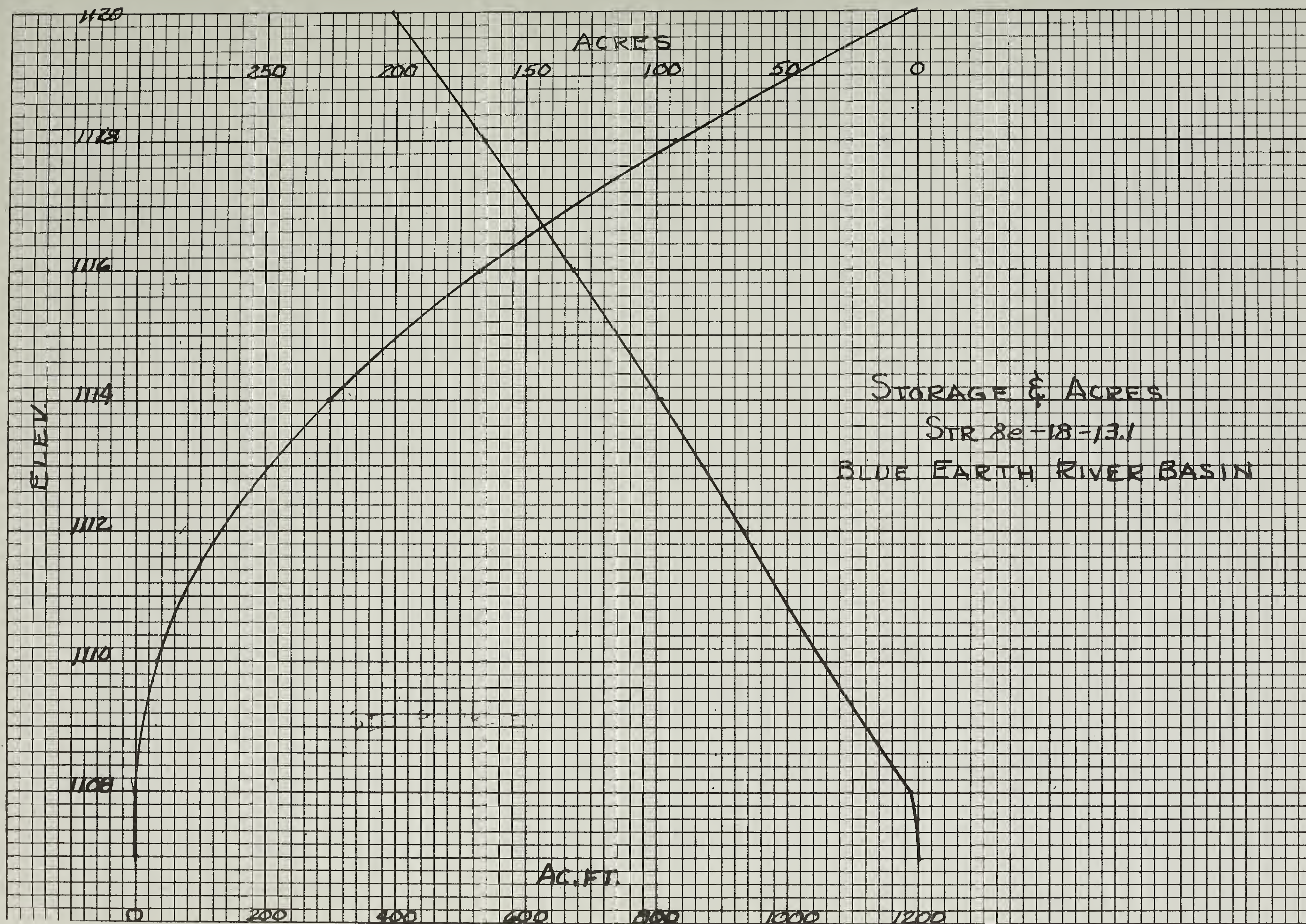
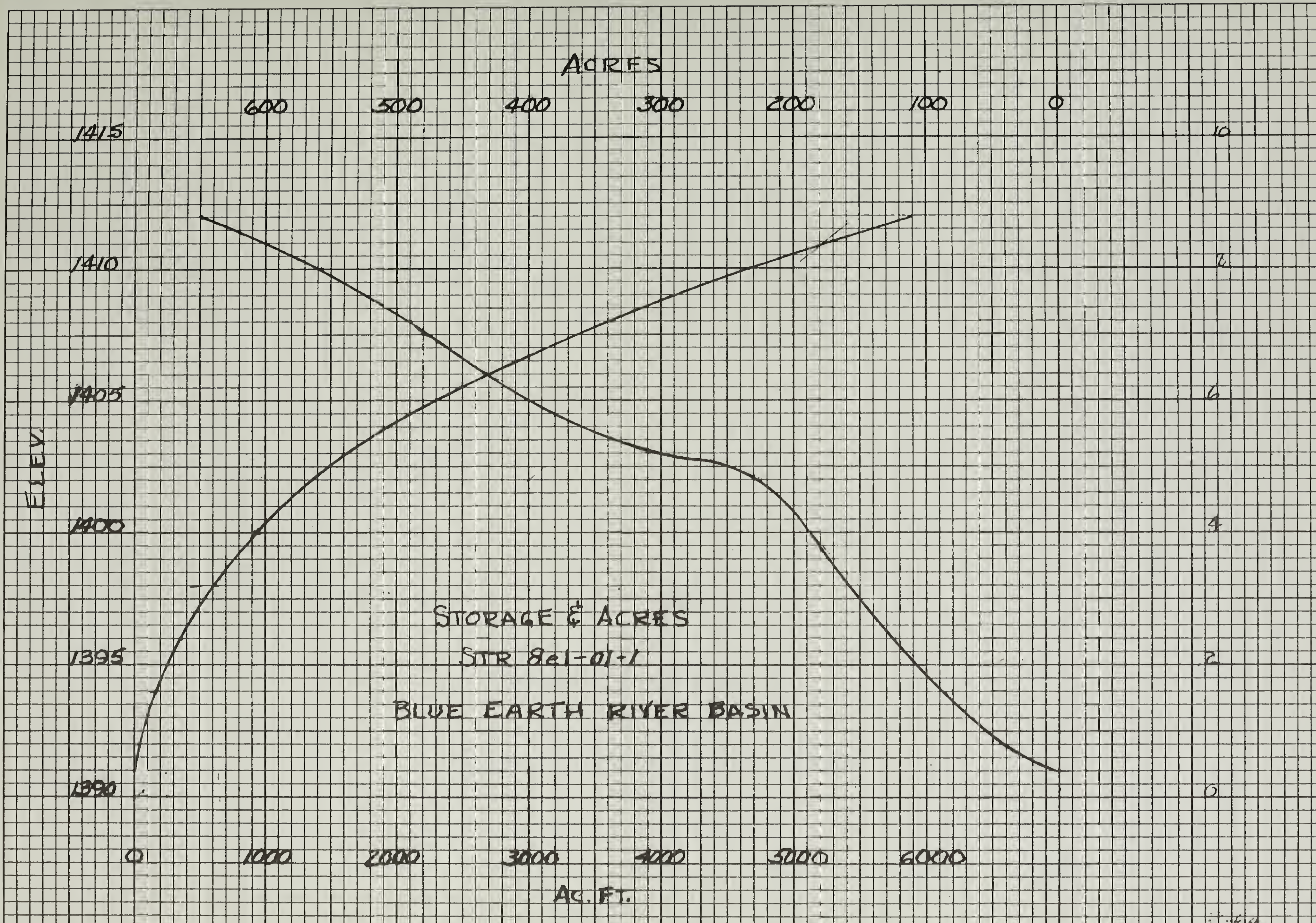
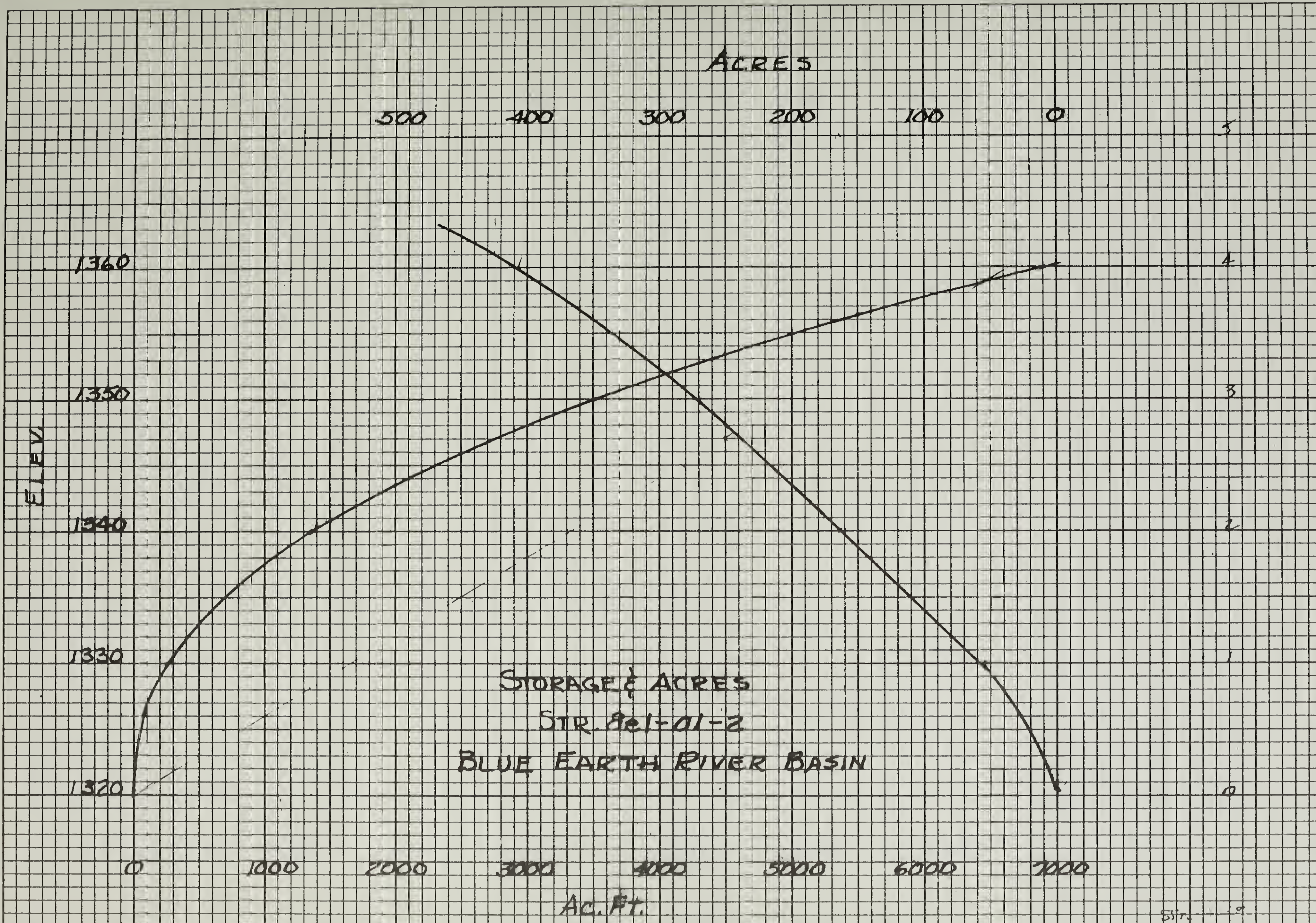
3000
4000
5000
6000
7000



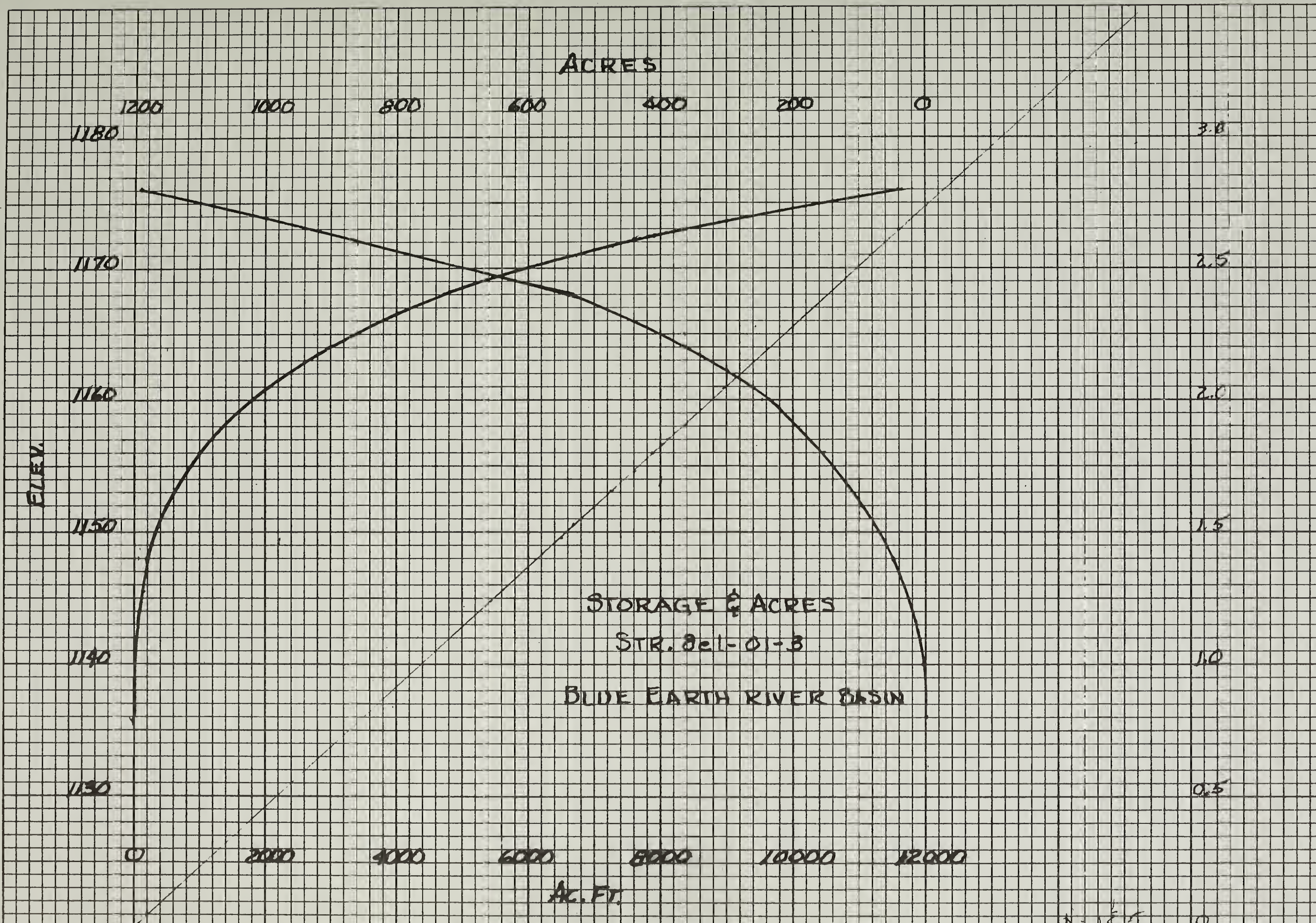
Storage & Acres
Str 8e-18-13.1
Blue Earth River Basin
Acres
250
200
150
100
50
0
Elev.
1120
1118
1116
1114
1112
1110
1108
Ac. Ft.
0
200
400
600
800
1000
1200

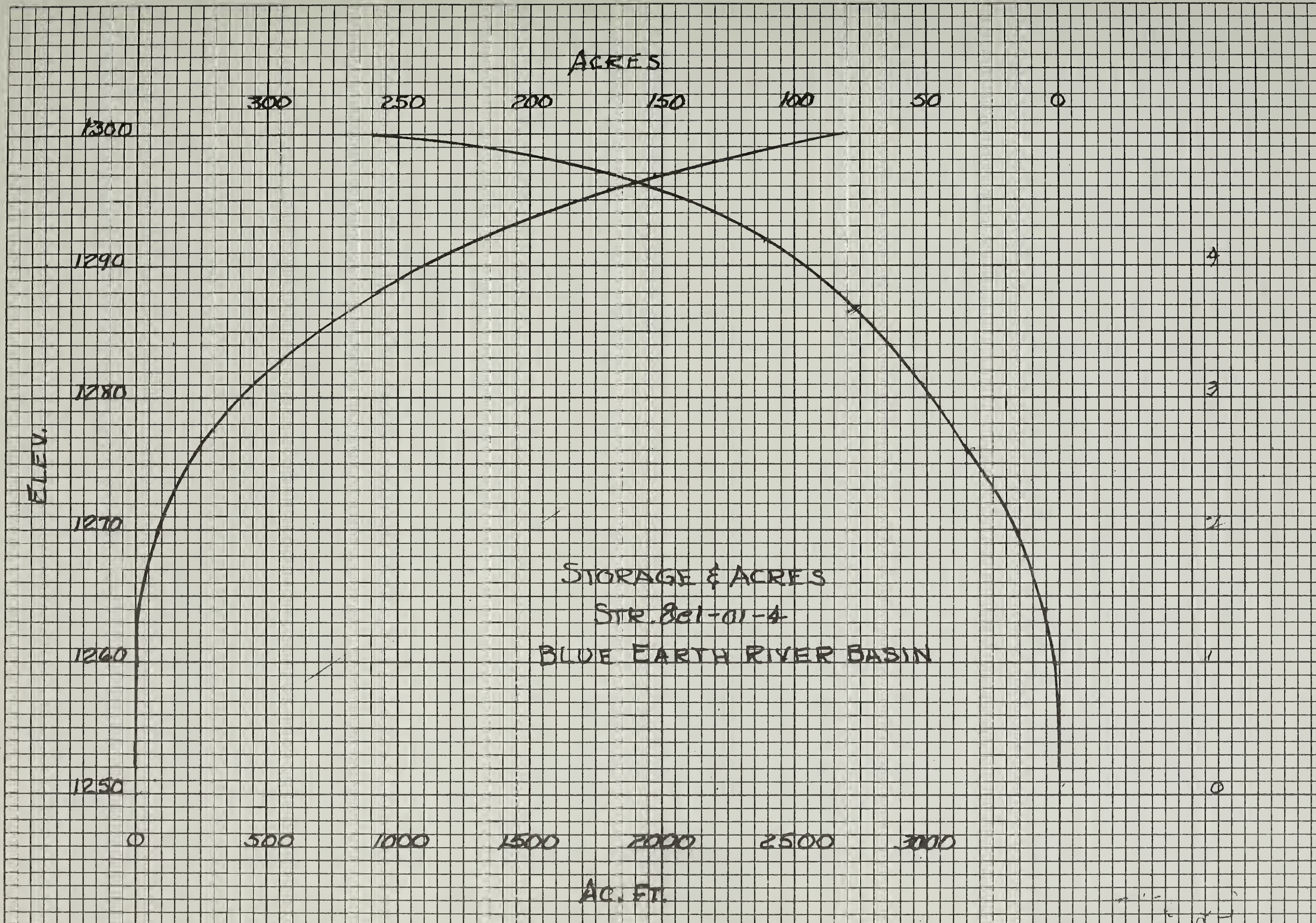
6


ACRES
600
500
400
300
200
100
0
1415
1410
1405
1400
1395
1390
ELEV.
10
8
6
4
2
0
STORAGE & ACRES
STR 8e1-01-1
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
AC. FT.

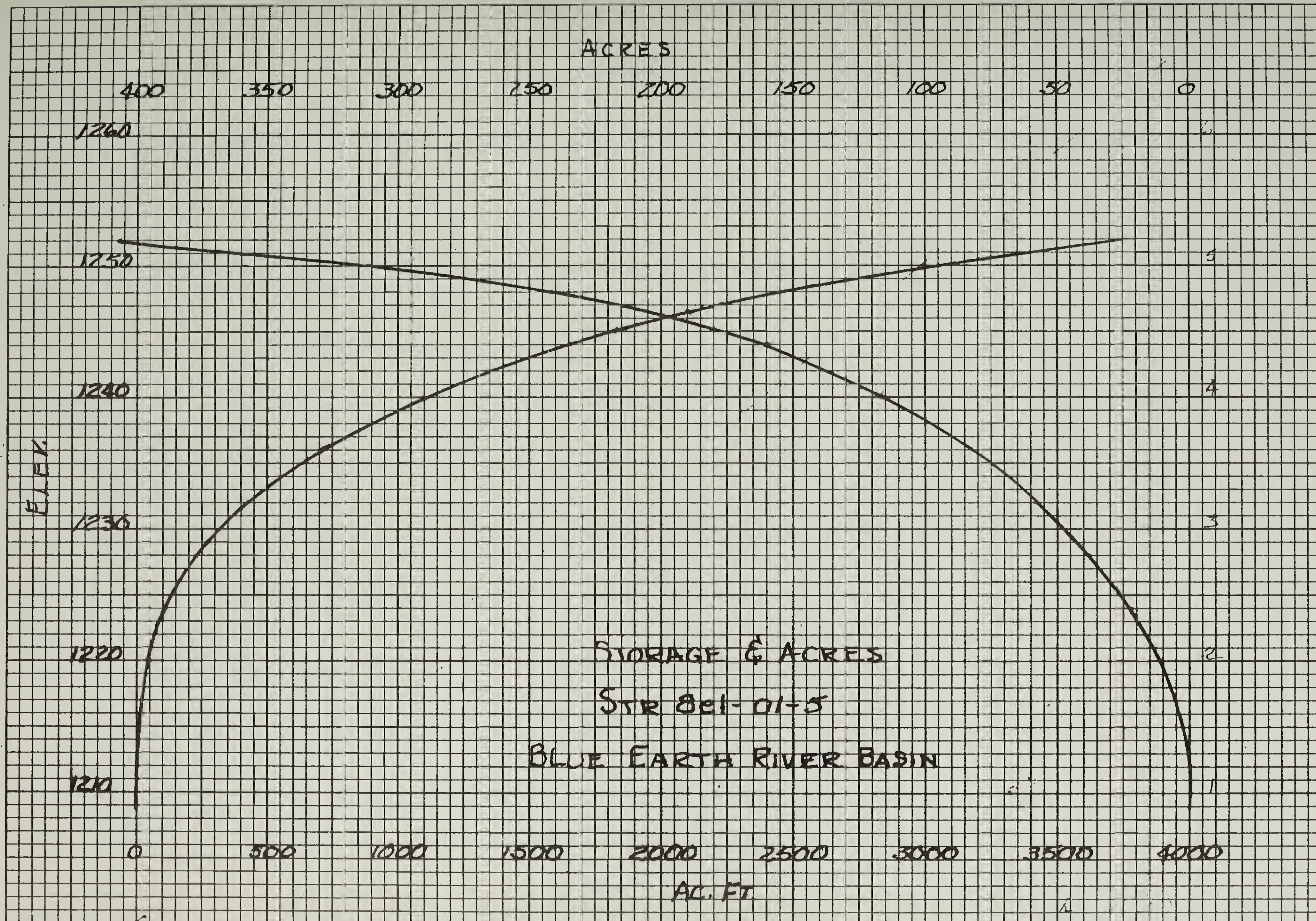


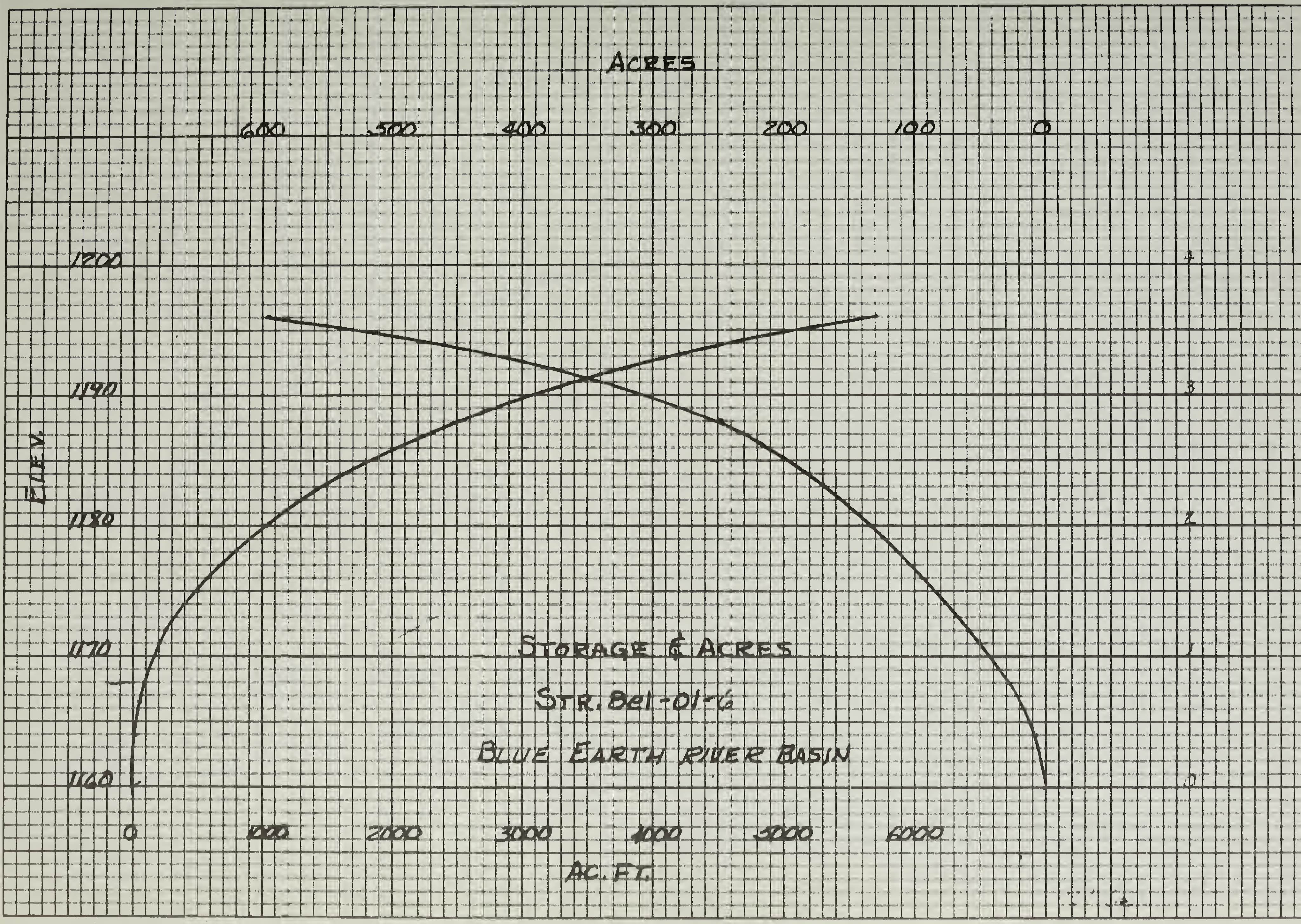
ACRES
500
400
300
200
100
0
1360
1350
1340
1330
1320
ELEV.
STORAGE & ACRES
STR. 8e1-01-2
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
7000
AC. FT.

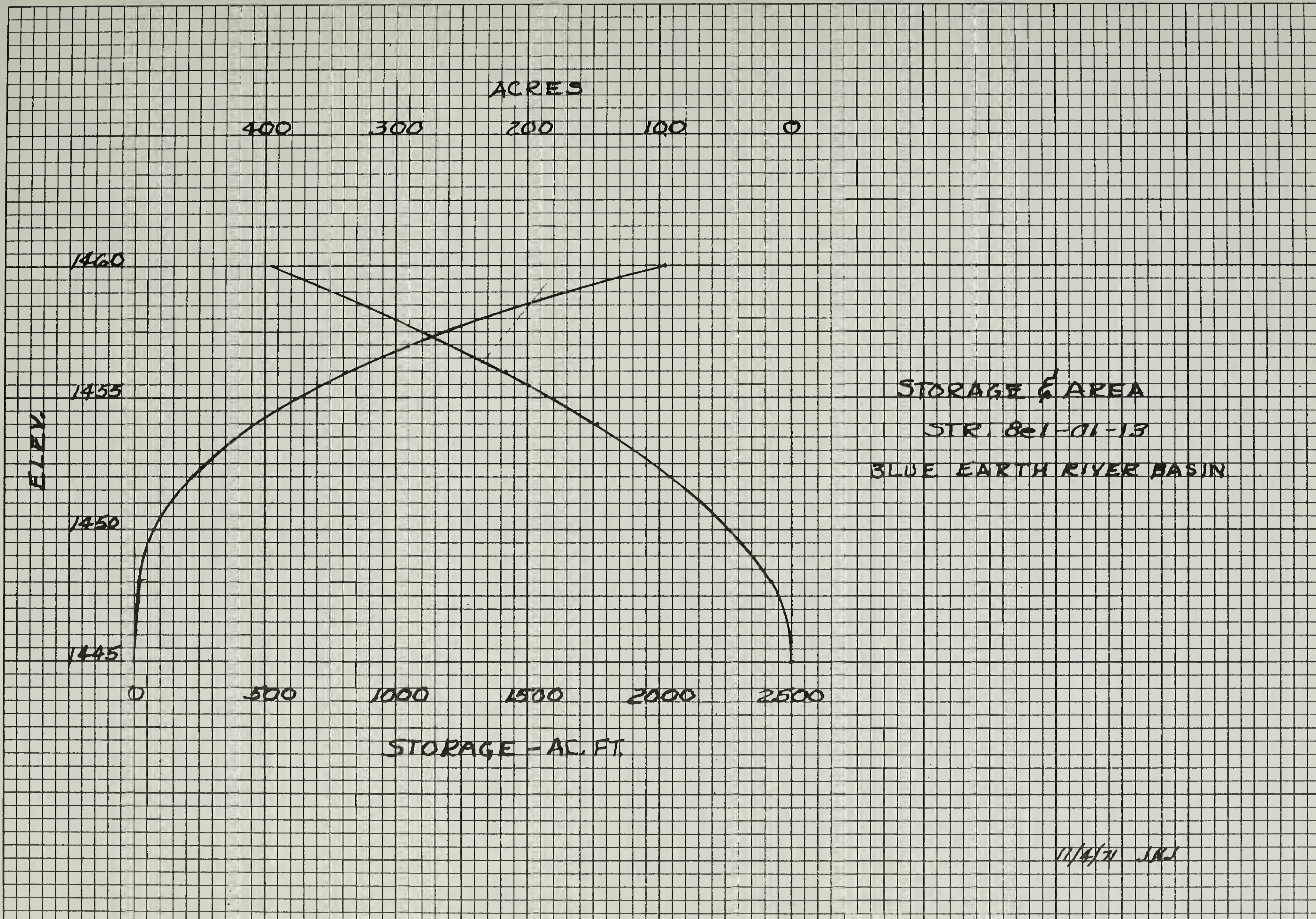

ACRES
1200
1000
800
600
400
200
0
1180
1170
1160
1150
1140
1130
ELEV.
3.0
2.5
2.0
1.5
1.0
0.5
0
STORAGE & ACRES
STR. 8e1-01-3
BLUE EARTH RIVER BASIN
0
2000
4000
6000
8000
10000
12000
AC. FT.



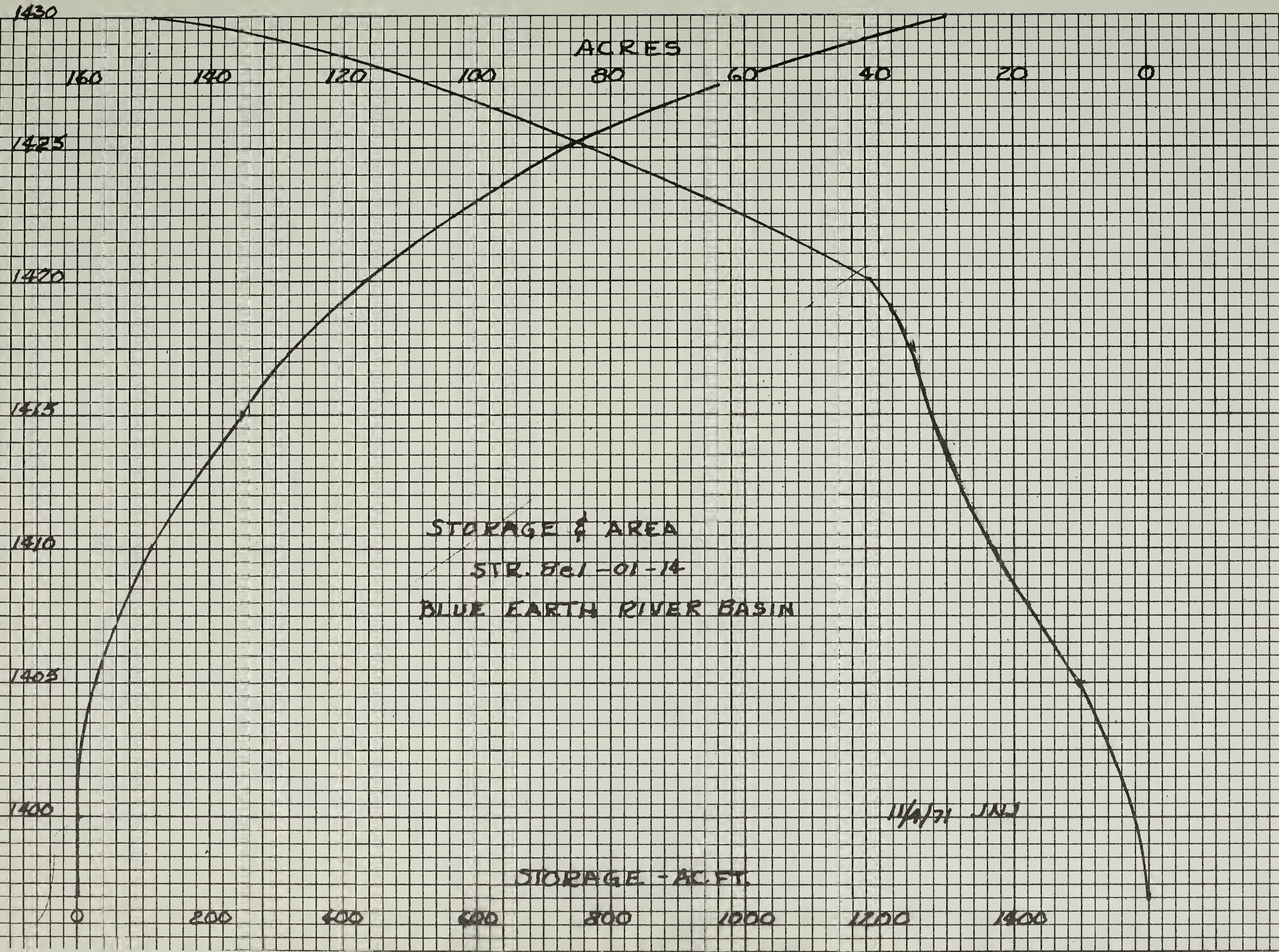
ACRES
300
250
200
150
100
50
0
1300
1290
1280
1270
1260
1250
ELEV.
4
3
2
1
0
STORAGE & ACRES
STR. 8c1-01-4
BLUE EARTH RIVER BASIN
0
500
1000
1500
2000
2500
3000
AC. FT.


ACRES
400
350
300
250
200
150
100
50
0
1260
1250
1240
1230
1220
1210
ELEV.
5
4
3
2
1
STORAGE & ACRES
STR 8el-01-5
BLUE EARTH RIVER BASIN
0
500
1000
1500
2000
2500
3000
3500
4000
AC. FT.

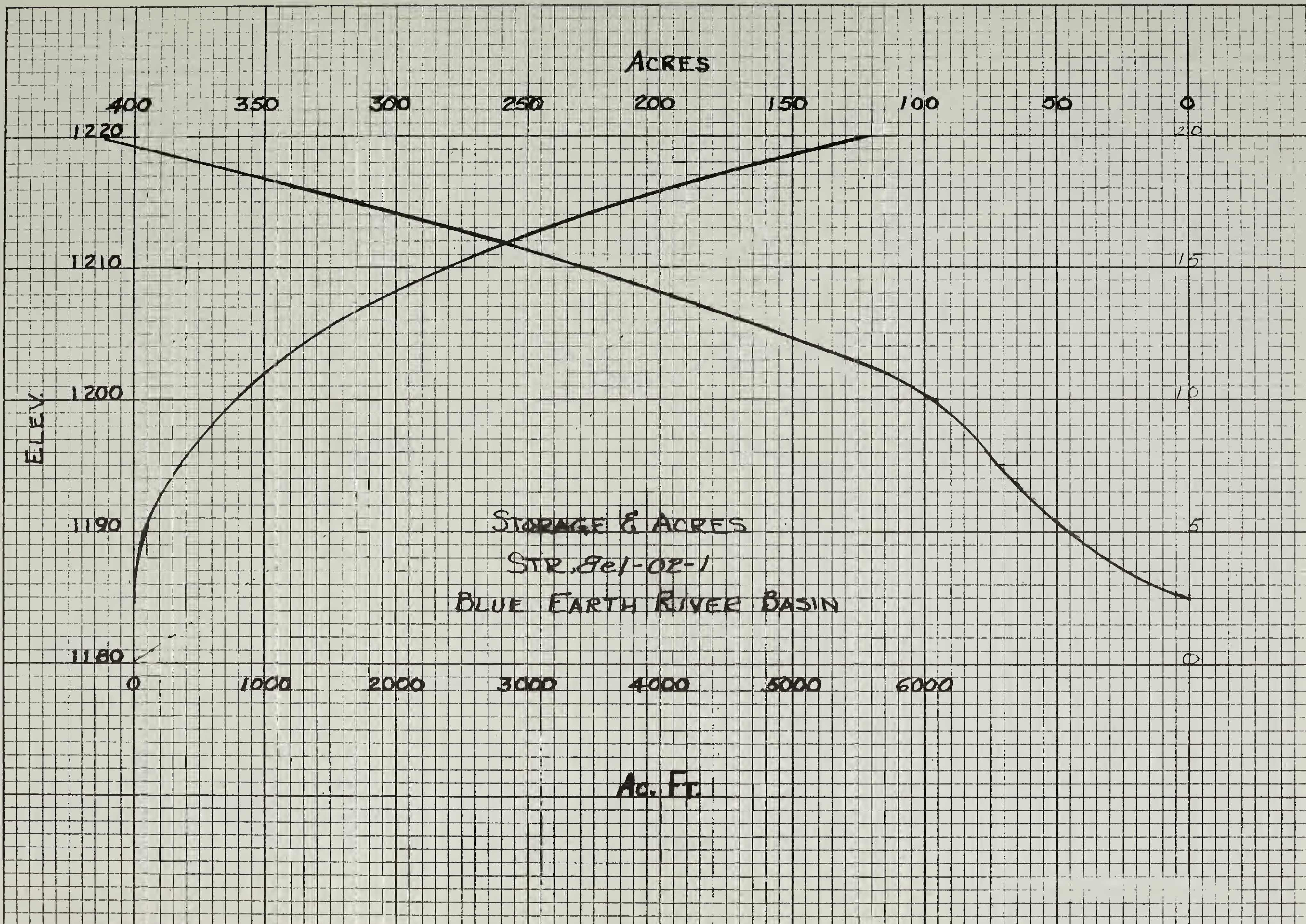

ACRES
600
500
400
300
200
100
0
ELEV.
1200
1190
1180
1170
1160
4
3
2
1
0
STORAGE & ACRES
STR. 8e1-01-6
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
AC. FT.



ACRES
400
300
200
100
0
1460
1455
1450
1445
ELEV.
0
500
1000
1500
2000
2500
STORAGE - AC. FT.
STORAGE & AREA
STR. 8e1-01-13
BLUE EARTH RIVER BASIN
11/4/71 JKJ

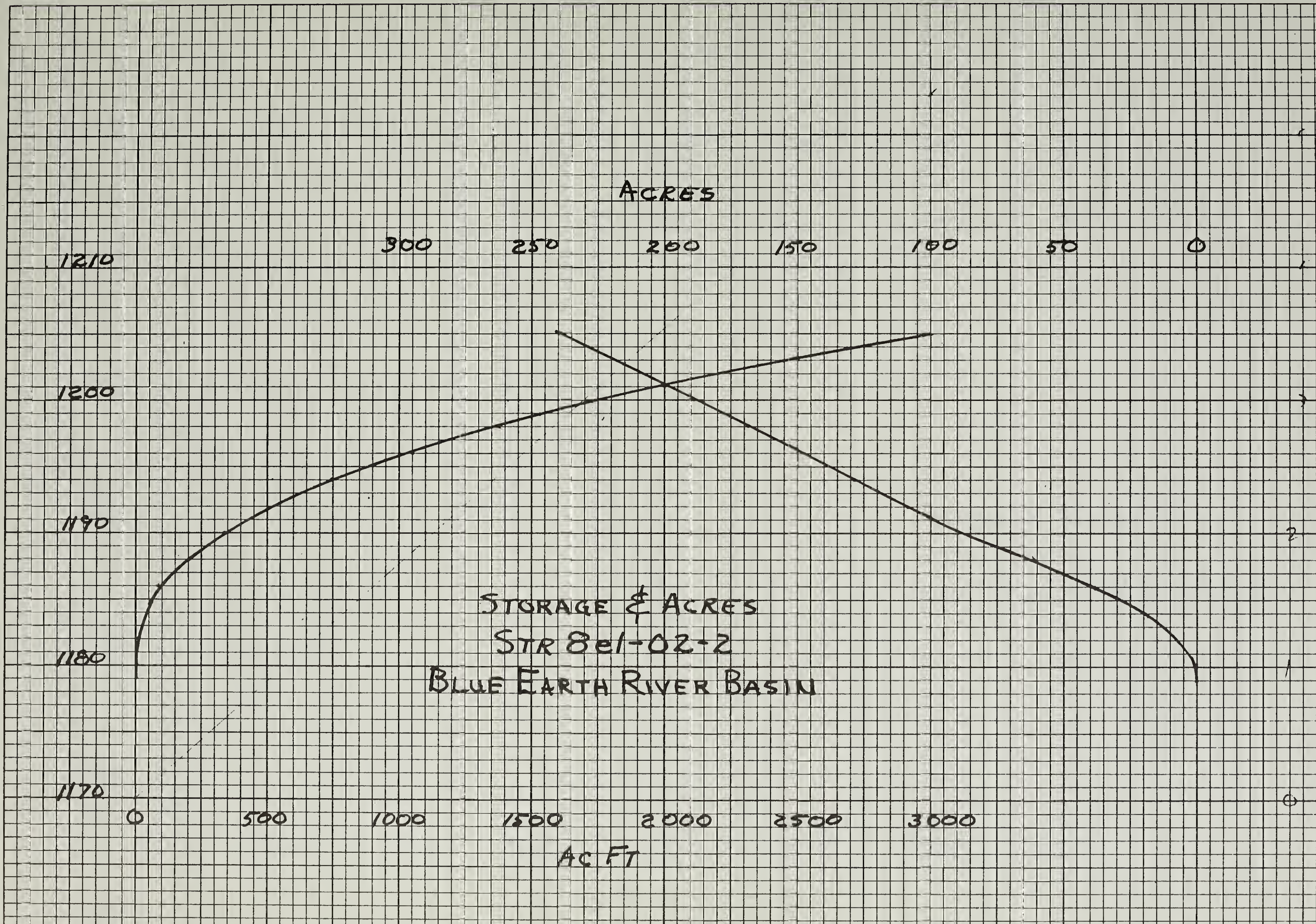


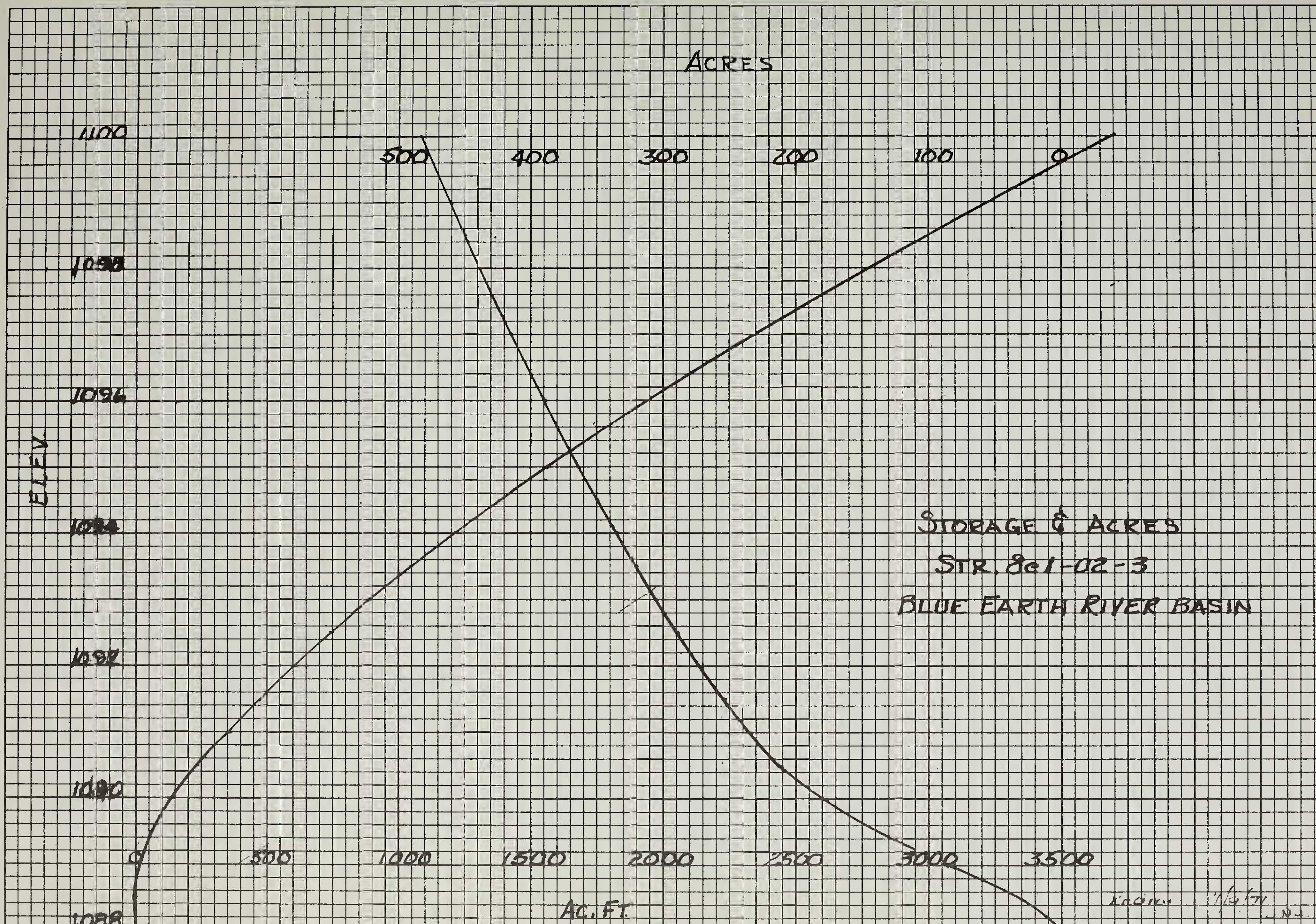
ACRES
160
140
120
100
80
60
40
20
0
1430
1425
1420
1415
1410
1405
1400
ELEV.
STORAGE & AREA
STR. 8e1-01-14
BLUE EARTH RIVER BASIN
11/4/71 JNJ
STORAGE - AC.FT.
0
200
400
600
800
1000
1200
1400



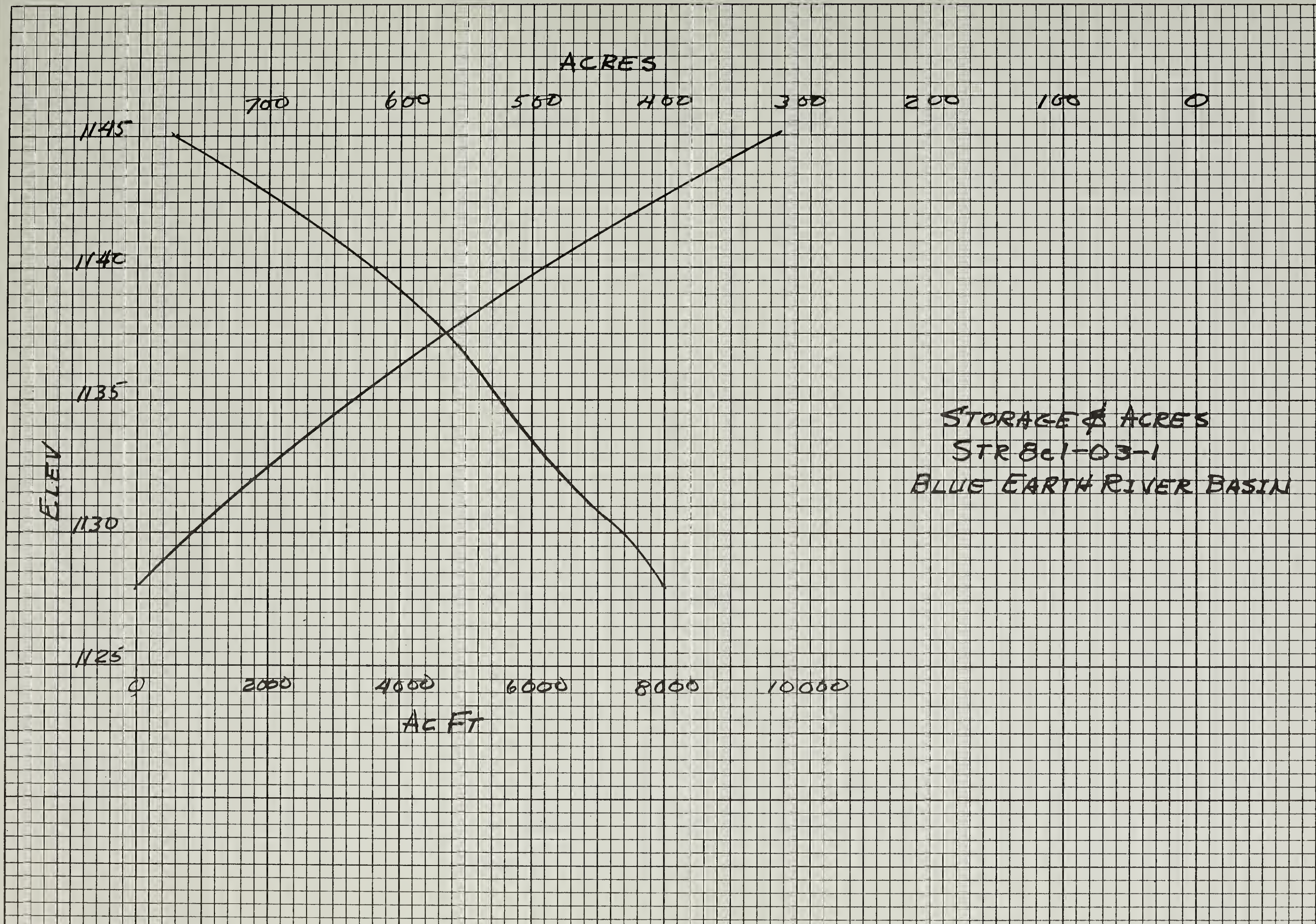
ACRES
400
350
300
250
200
150
100
50
0
1220
1210
1200
1190
1180
ELEV.
20
15
10
5
0
STORAGE & ACRES
STR. Bel-02-1
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
AC. FT.

35

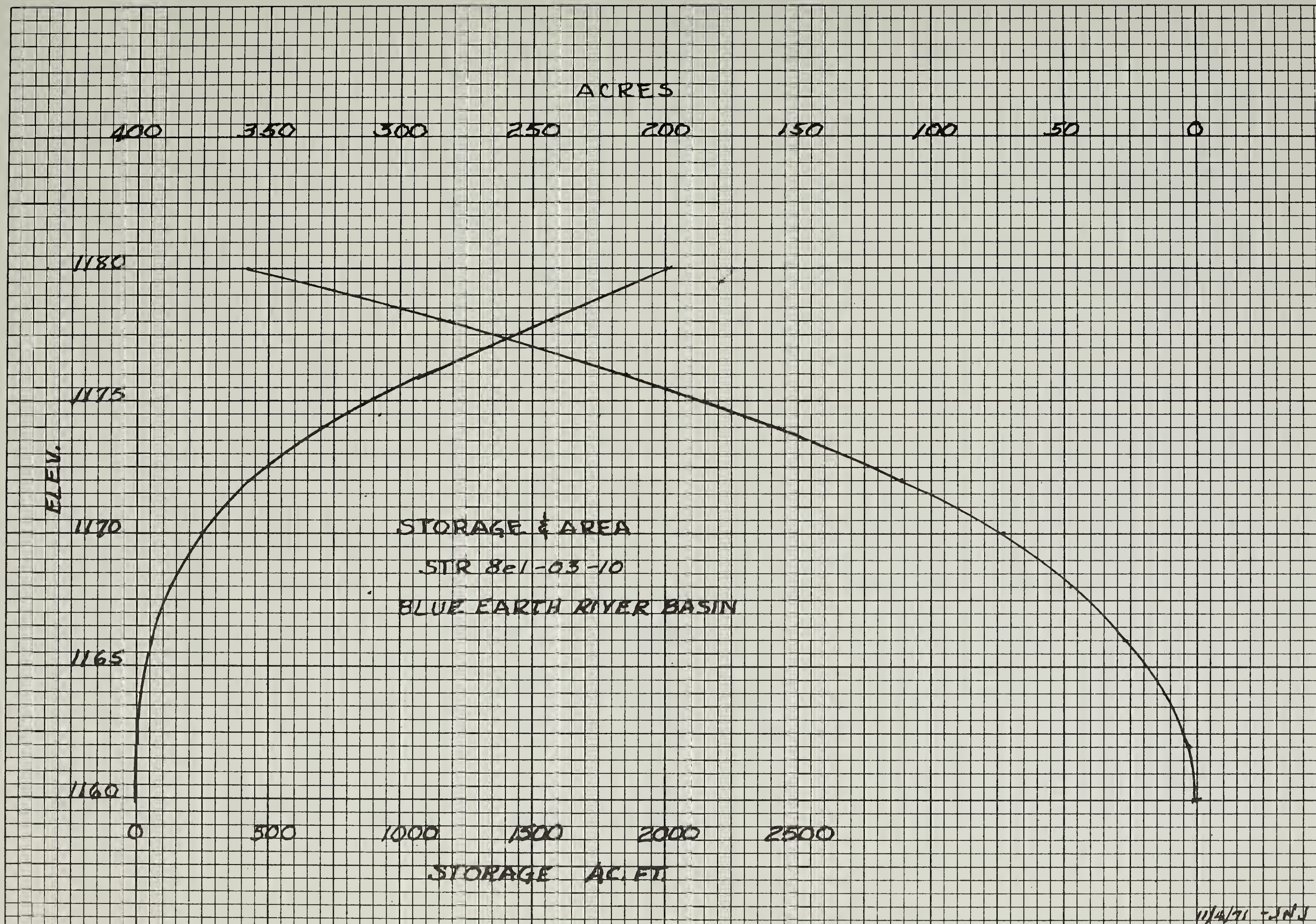

ACRES
300
250
200
150
100
50
0
STORAGE & ACRES
STR 8el-02-2
BLUE EARTH RIVER BASIN
1210
1200
1190
1180
1170
0
500
1000
1500
2000
2500
3000
AC FT



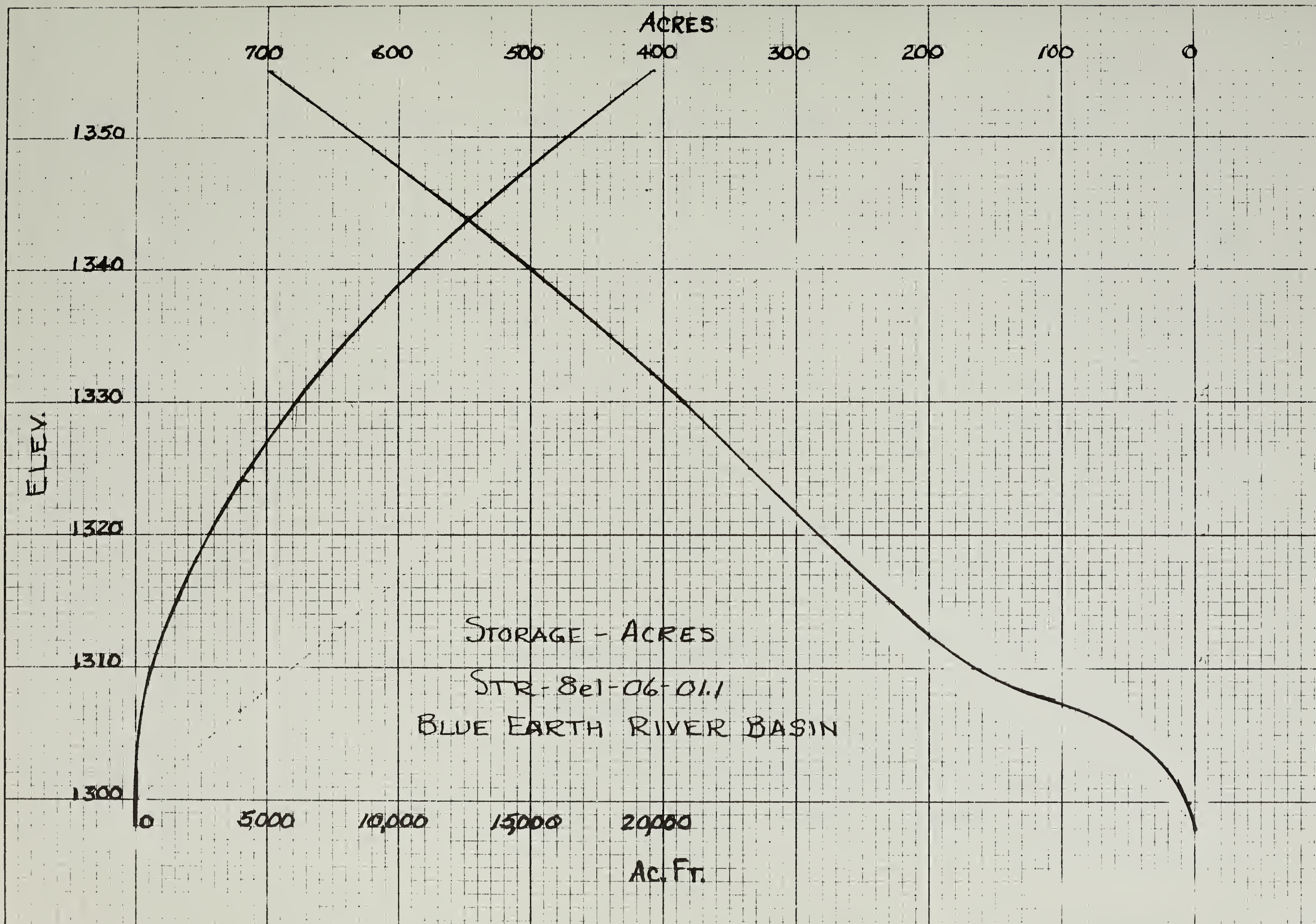
ACRES
500
400
300
200
100
0
1100
1098
1096
1094
1092
1090
1088
ELEV.
0
500
1000
1500
2000
2500
3000
3500
AC. FT.
STORAGE & ACRES
STR. 8a1-02-3
BLUE EARTH RIVER BASIN

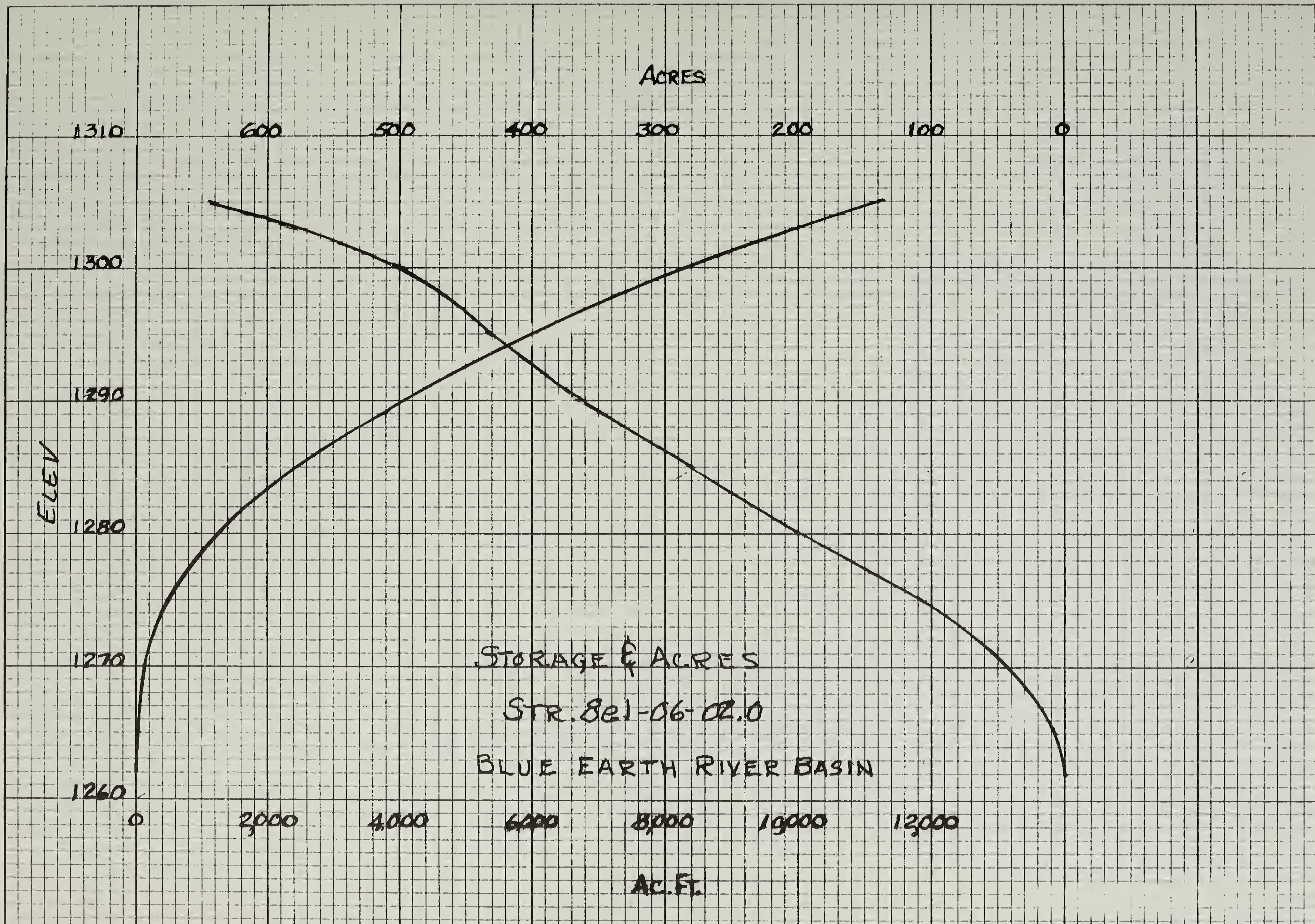


ACRES
700
600
500
400
300
200
100
0
1145
1140
1135
1130
1125
ELEV
0
2000
4000
6000
8000
10000
Ac Ft
STORAGE & ACRES
STR 8c1-03-1
BLUE EARTH RIVER BASIN

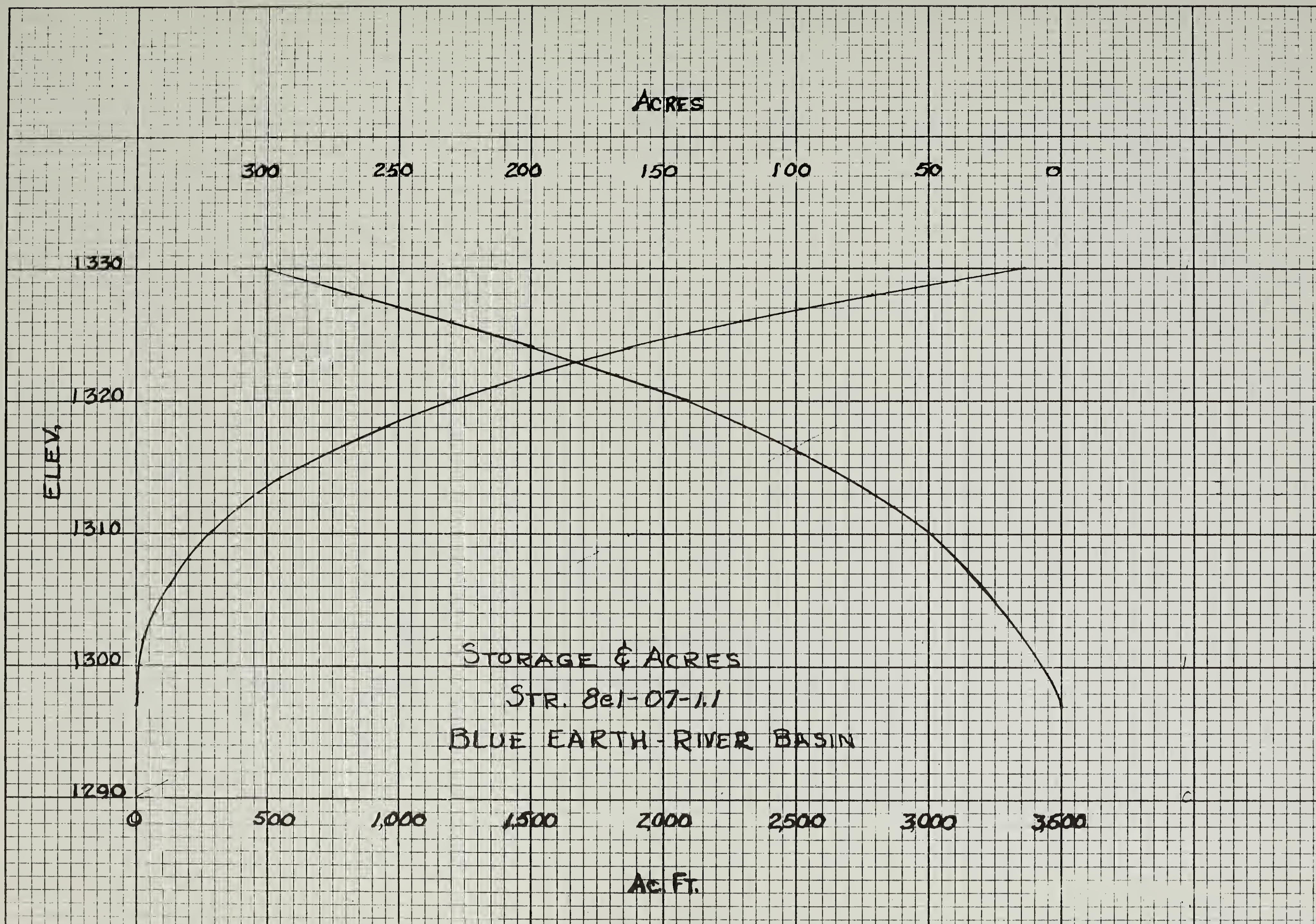


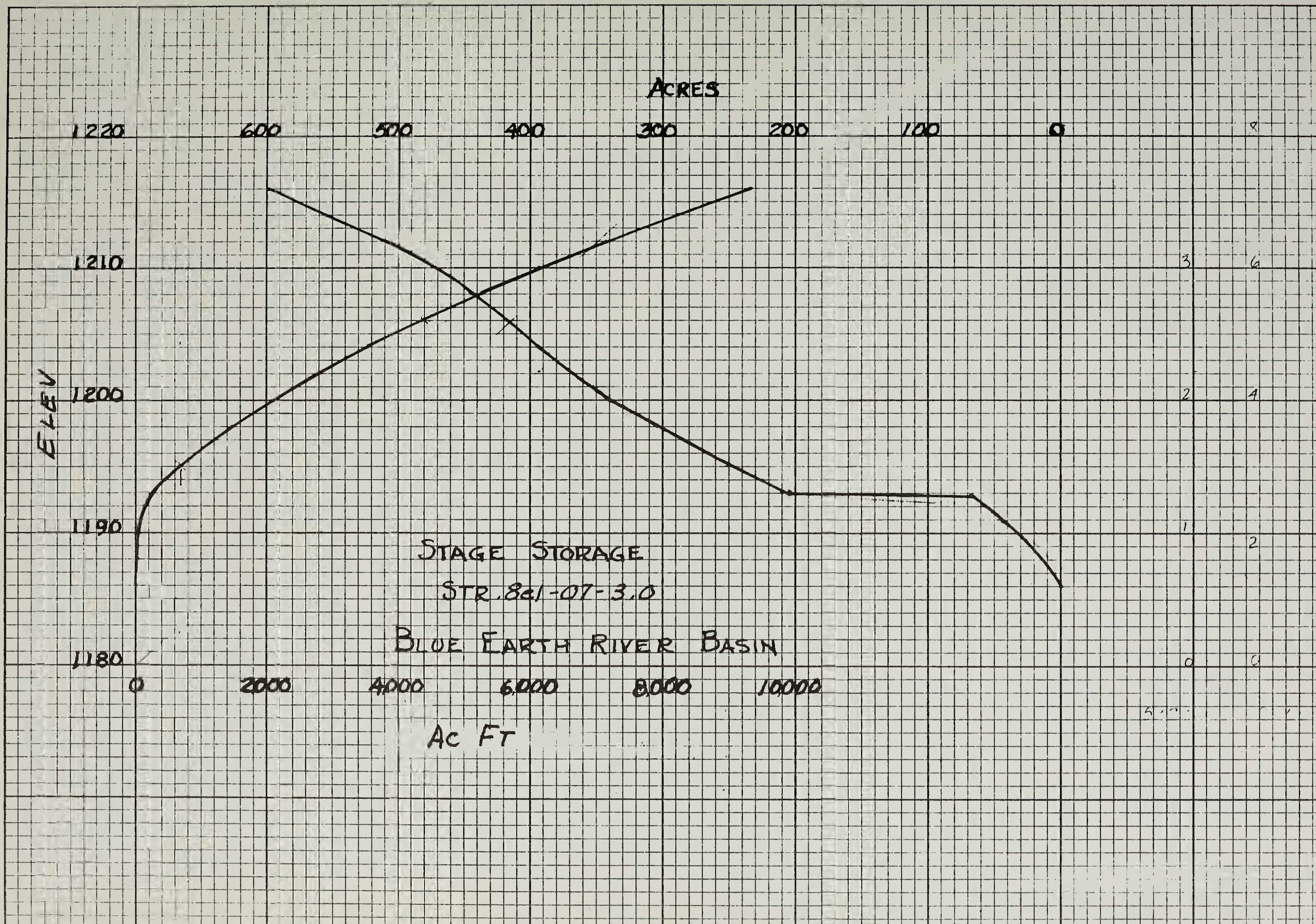
ACRES
400
350
300
250
200
150
100
50
0
ELEV.
1180
1175
1170
1165
1160
STORAGE & AREA
STR 8e1-03-10
BLUE EARTH RIVER BASIN
0
500
1000
1500
2000
2500
STORAGE AC. FT.
11/4/71 -JNJ

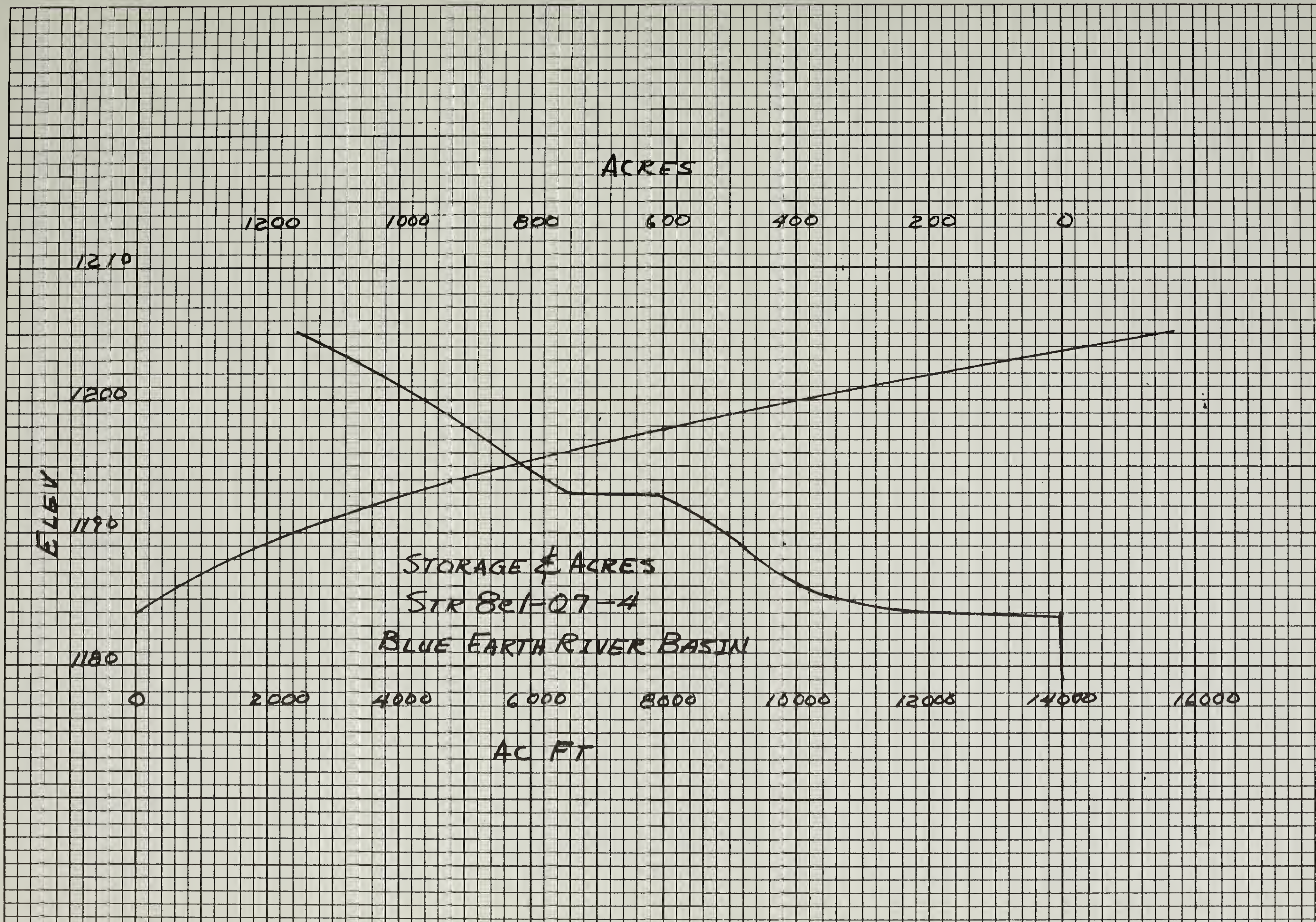

ACRES
700
600
500
400
300
200
100
0
1350
1340
1330
1320
1310
1300
ELEV.
STORAGE - ACRES
STR-8el-06-01.1
BLUE EARTH RIVER BASIN
0
5,000
10,000
15,000
20,000
AC. FT.

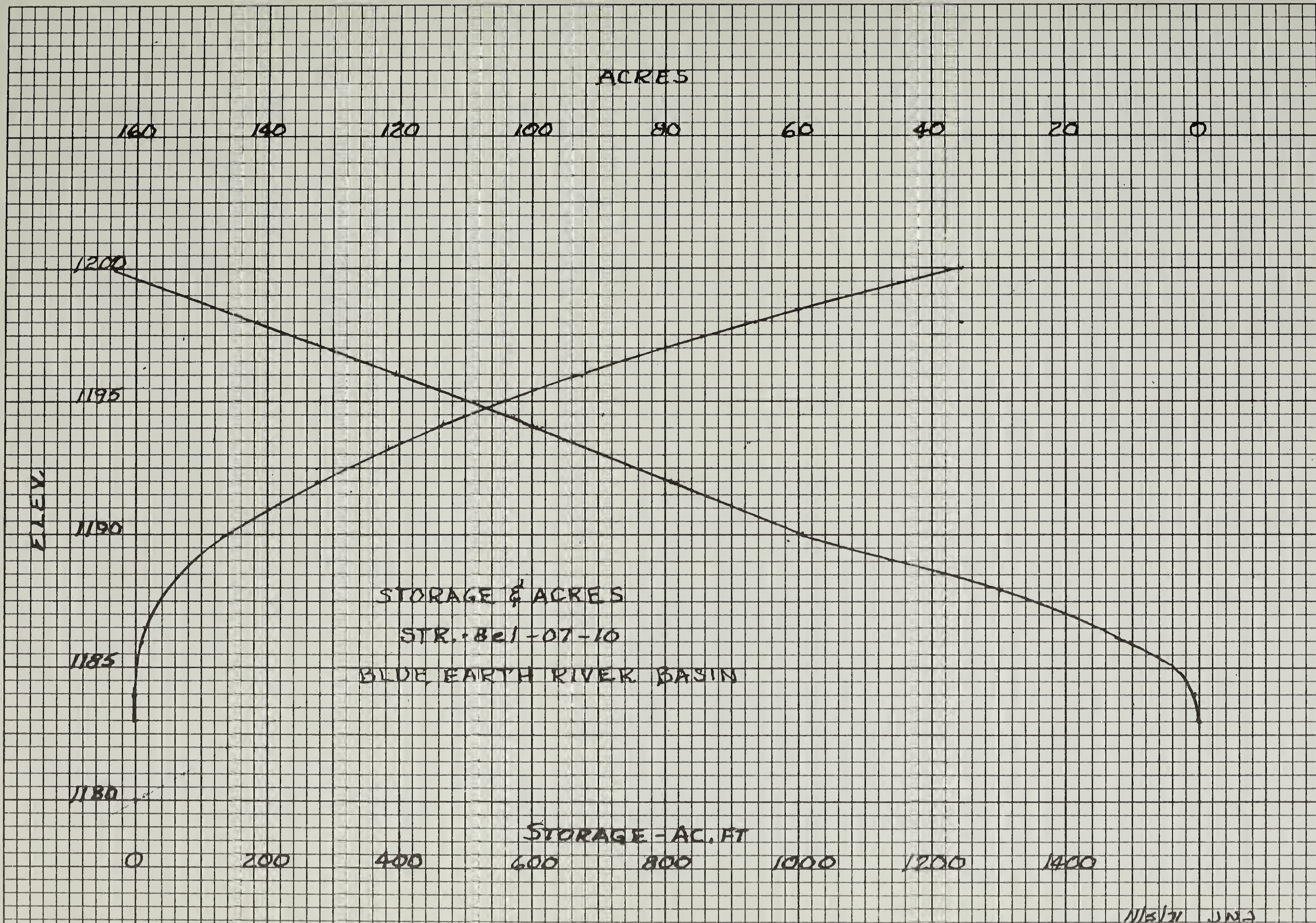

STORAGE & ACRES
STR. 8e1-06-02.0
BLUE EARTH RIVER BASIN
ACRES
600
500
400
300
200
100
0
ELEV
1310
1300
1290
1280
1270
1260
0
2,000
4,000
6,000
8,000
10,000
12,000
Ac. Ft.

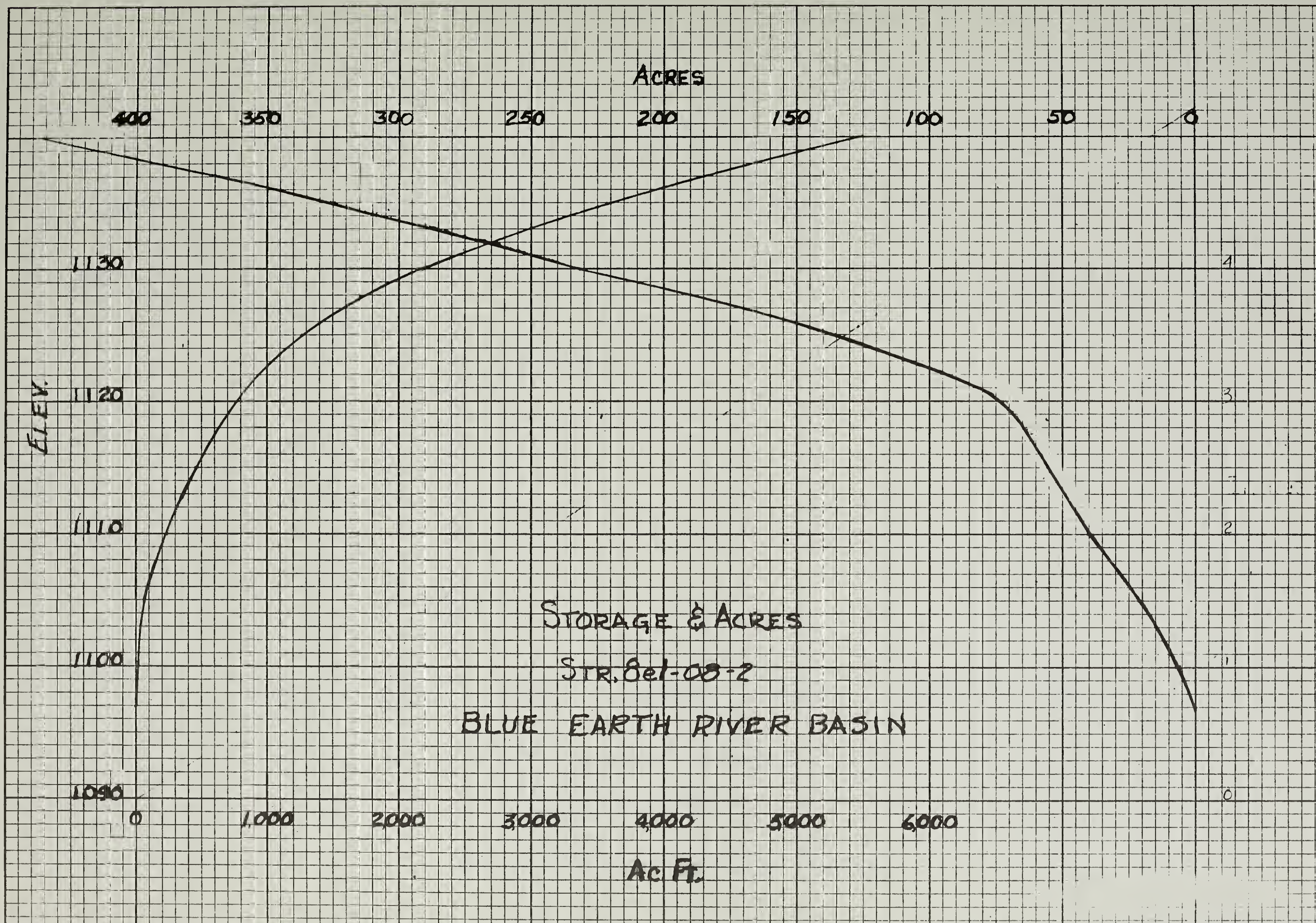
41

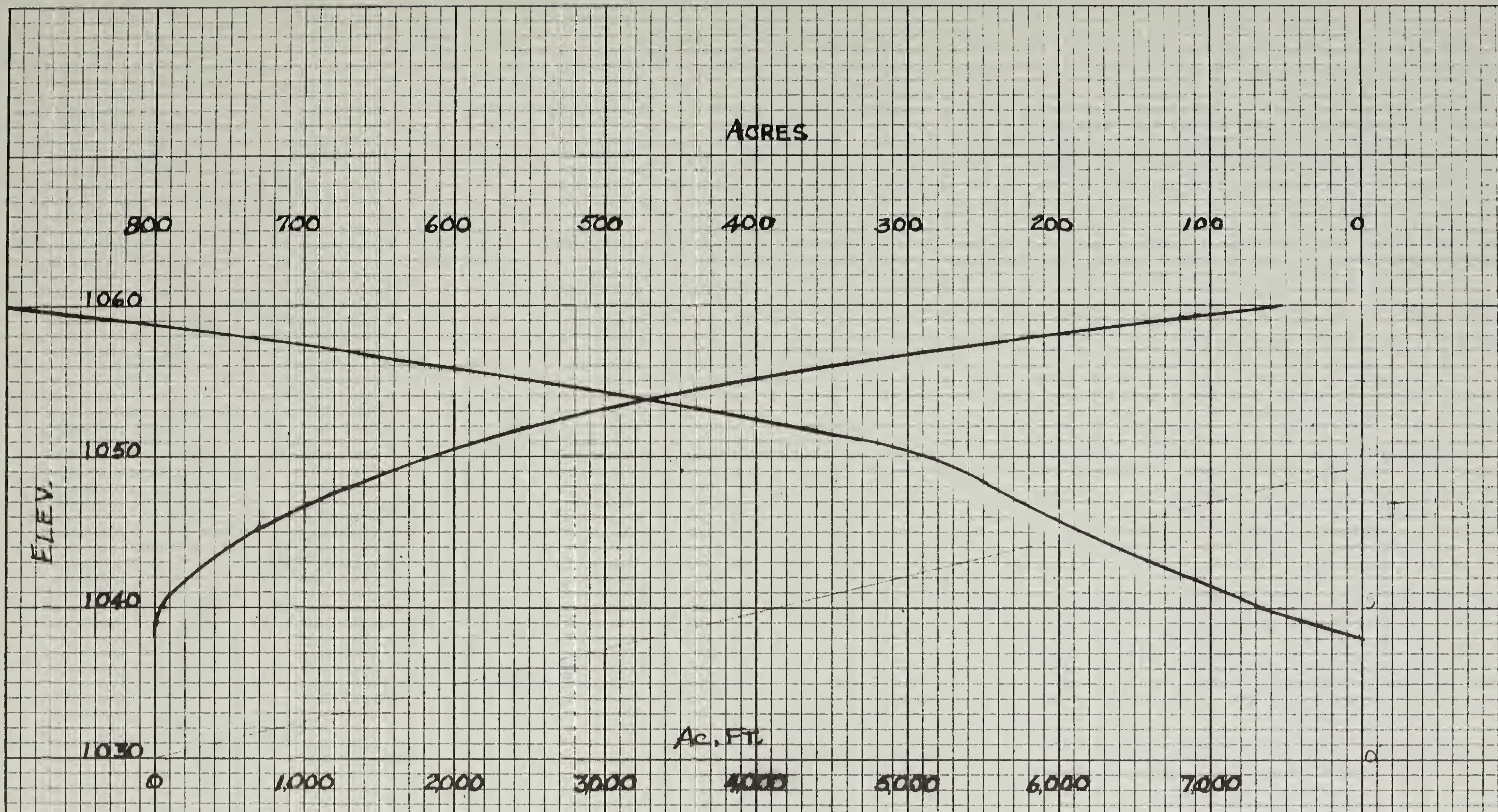

ACRES
300
250
200
150
100
50
0
1330
1320
ELEV.
1310
1300
1290
STORAGE & ACRES
STR. 8el-07-1.1
BLUE EARTH-RIVER BASIN
0
500
1,000
1,500
2,000
2,500
3,000
3,500
Ac. Ft.


Acres
1220
600
500
400
300
200
100
0
1210
1200
1190
1180
Elev
Stage Storage
Str. 8a1-07-3.0
Blue Earth River Basin
0
2000
4000
6000
8000
10000
Ac Ft


ACRES
1200
1000
800
600
400
200
0
1210
1200
1190
1180
ELEV
STORAGE & ACRES
STR 8el-07-4
BLUE EARTH RIVER BASIN
0
2000
4000
6000
8000
10000
12000
14000
16000
AC FT


ACRES
160
140
120
100
80
60
40
20
0
1200
1195
1190
1185
1180
ELEV.
STORAGE & ACRES
STR. 8el-07-10
BLUE EARTH RIVER BASIN
STORAGE - AC. FT
0
200
400
600
800
1000
1200
1400
11/3/71 JNJ

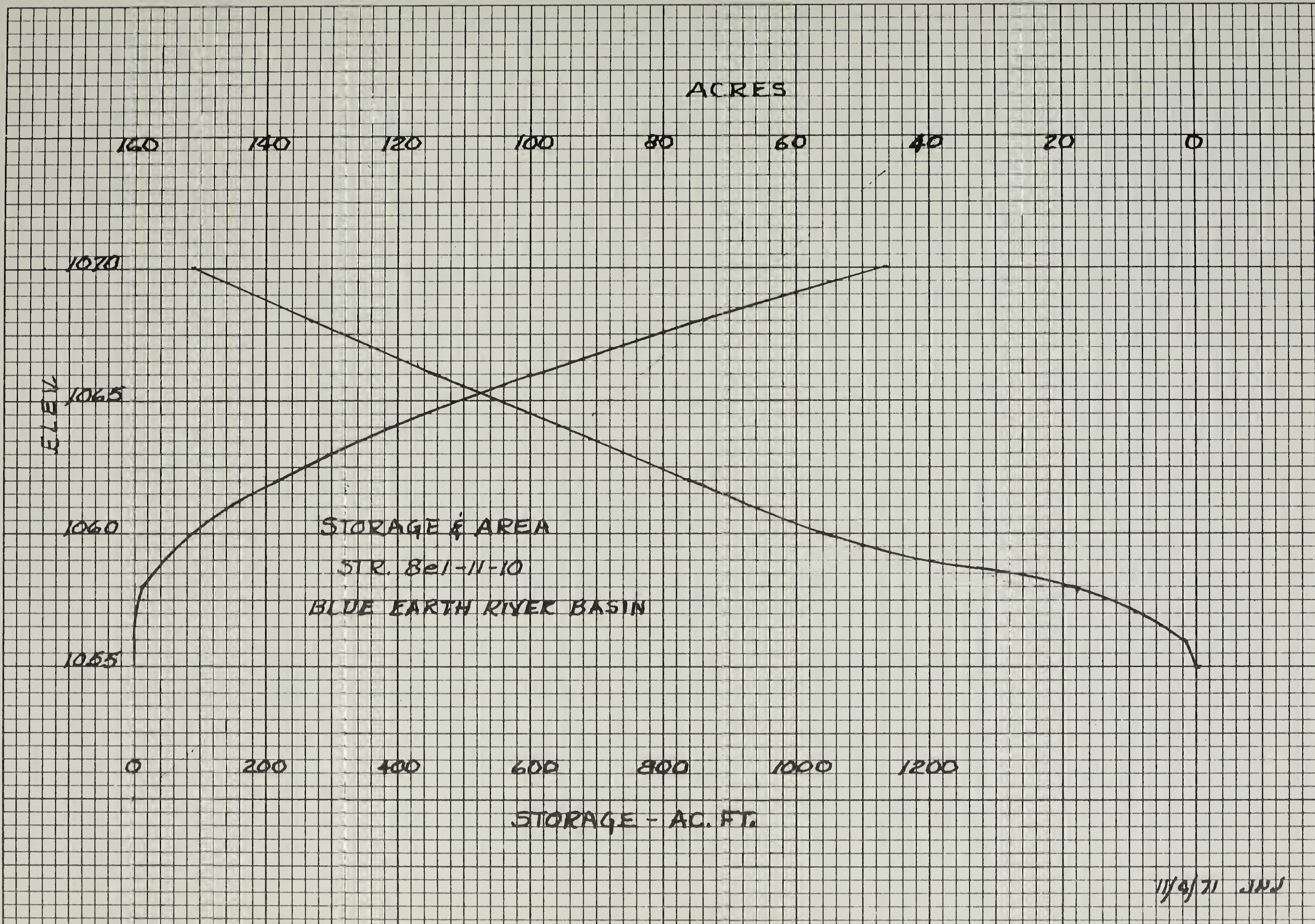

STORAGE & ACRES
STR. 8e1-08-2
BLUE EARTH RIVER BASIN
ACRES
400
350
300
250
200
150
100
50
0
ELEV.
1130
1120
1110
1100
1090
4
3
2
1
0
0
1,000
2000
3000
4000
5000
6000
Ac Ft.



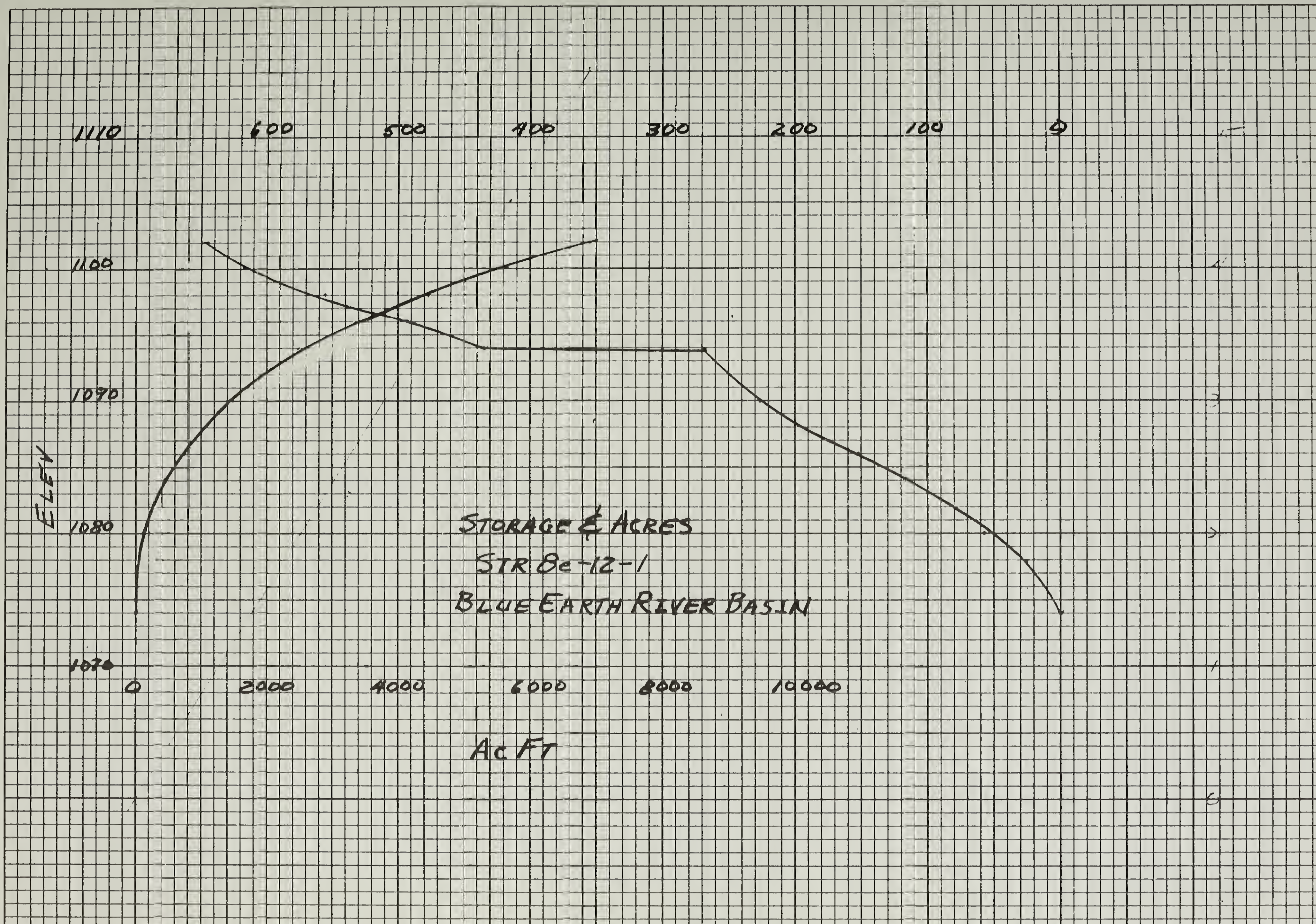
STORAGE & ACRES

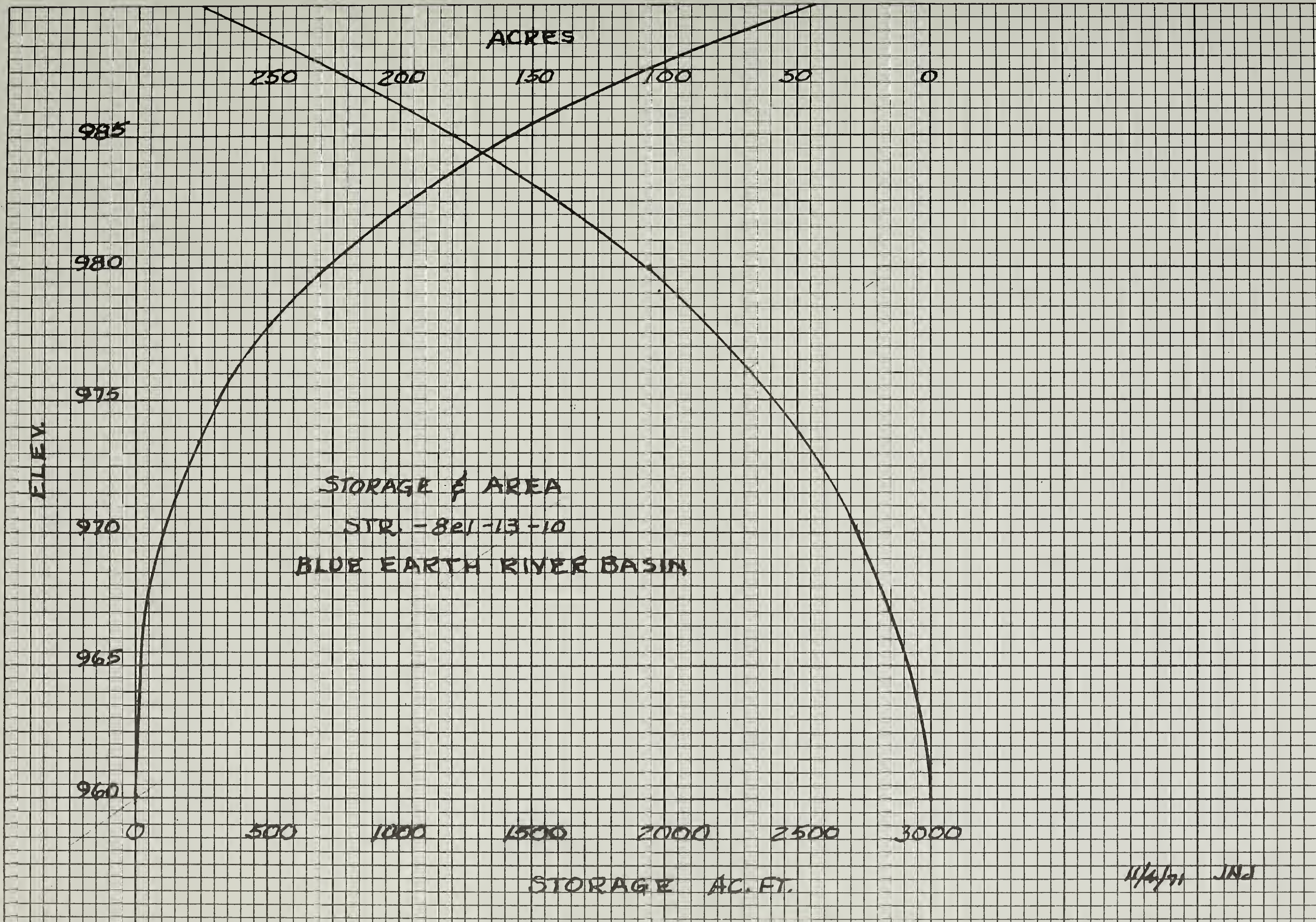
STR. 8e1-11-1

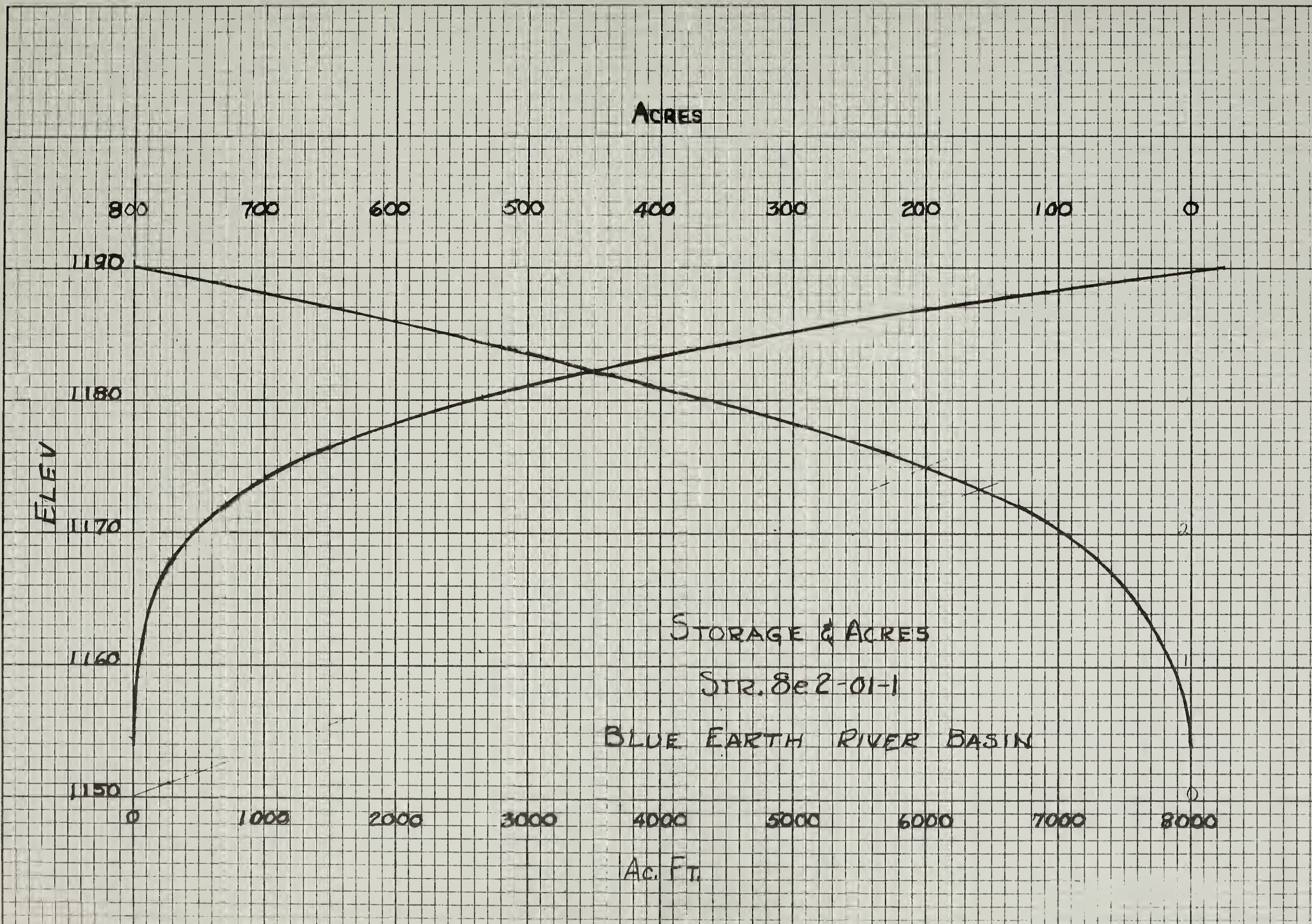
BLUE EARTH RIVER BASIN



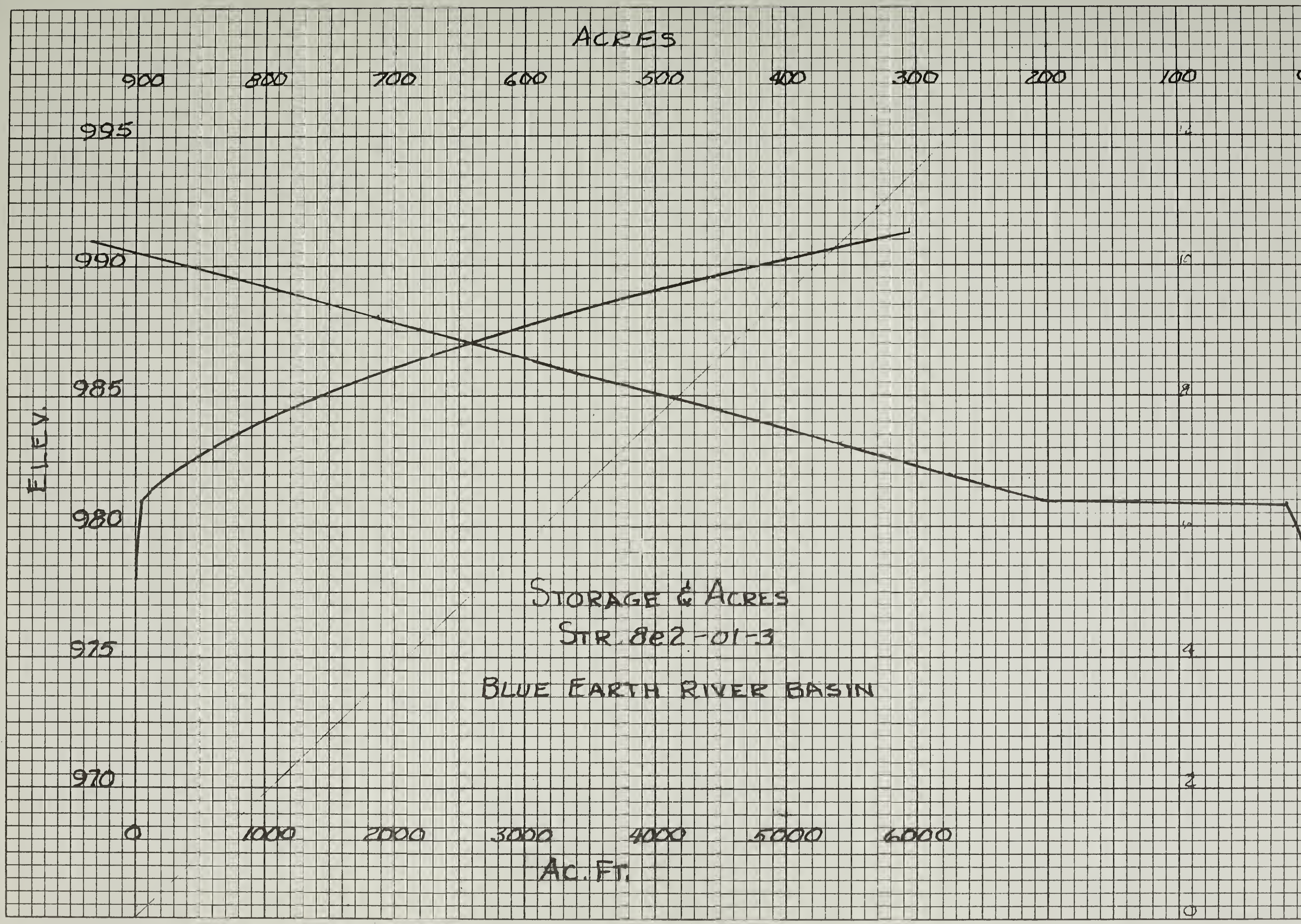
ACRES
160
140
120
100
80
60
40
20
0
ELEV.
1070
1065
1060
1055
STORAGE & AREA
STR. 8e1-11-10
BLUE EARTH RIVER BASIN
0
200
400
600
800
1000
1200
STORAGE - AC. FT.
11/4/71 JNJ

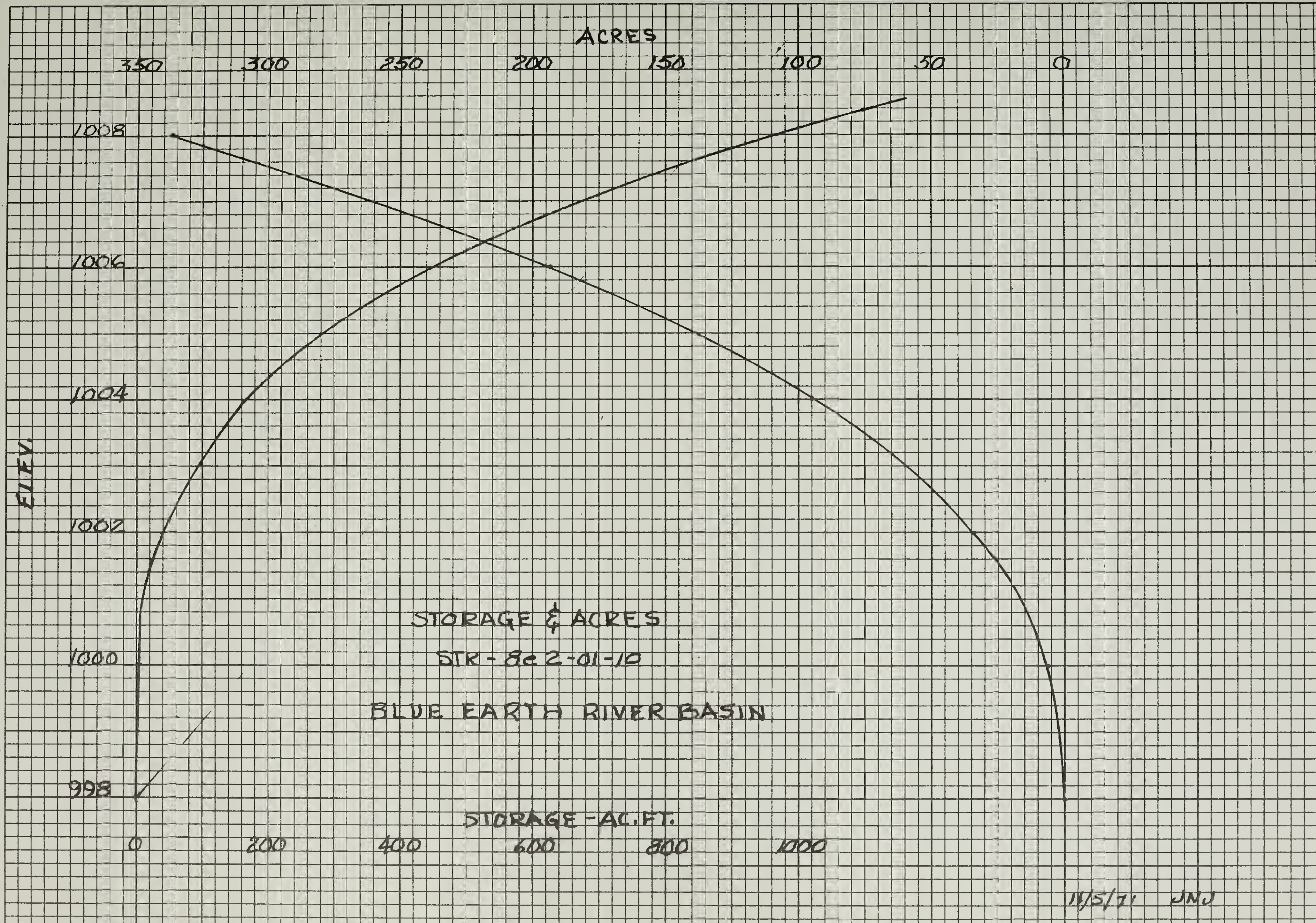

1110
600
500
400
300
200
100
0
1100
1090
ELEV
1080
1070
0
2000
4000
6000
8000
10000
STORAGE & ACRES
STR 8c-12-1
BLUE EARTH RIVER BASIN
Ac FT

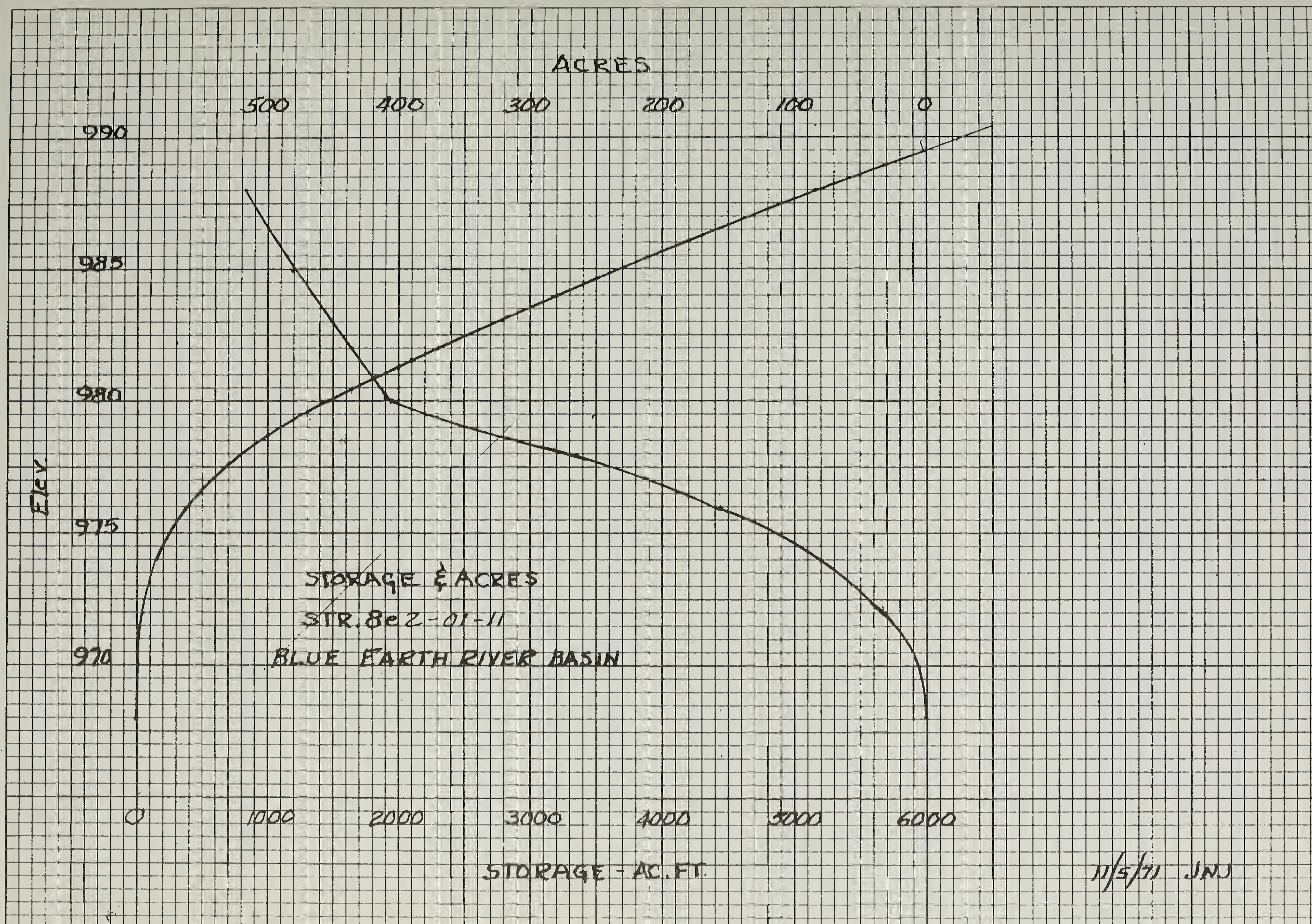

ACRES
250
200
150
100
50
0
985
980
975
970
965
960
ELEV.
STORAGE & AREA
STR. -8e1-13-10
BLUE EARTH RIVER BASIN
0
500
1000
1500
2000
2500
3000
STORAGE AC. FT.
11/4/71 JNJ

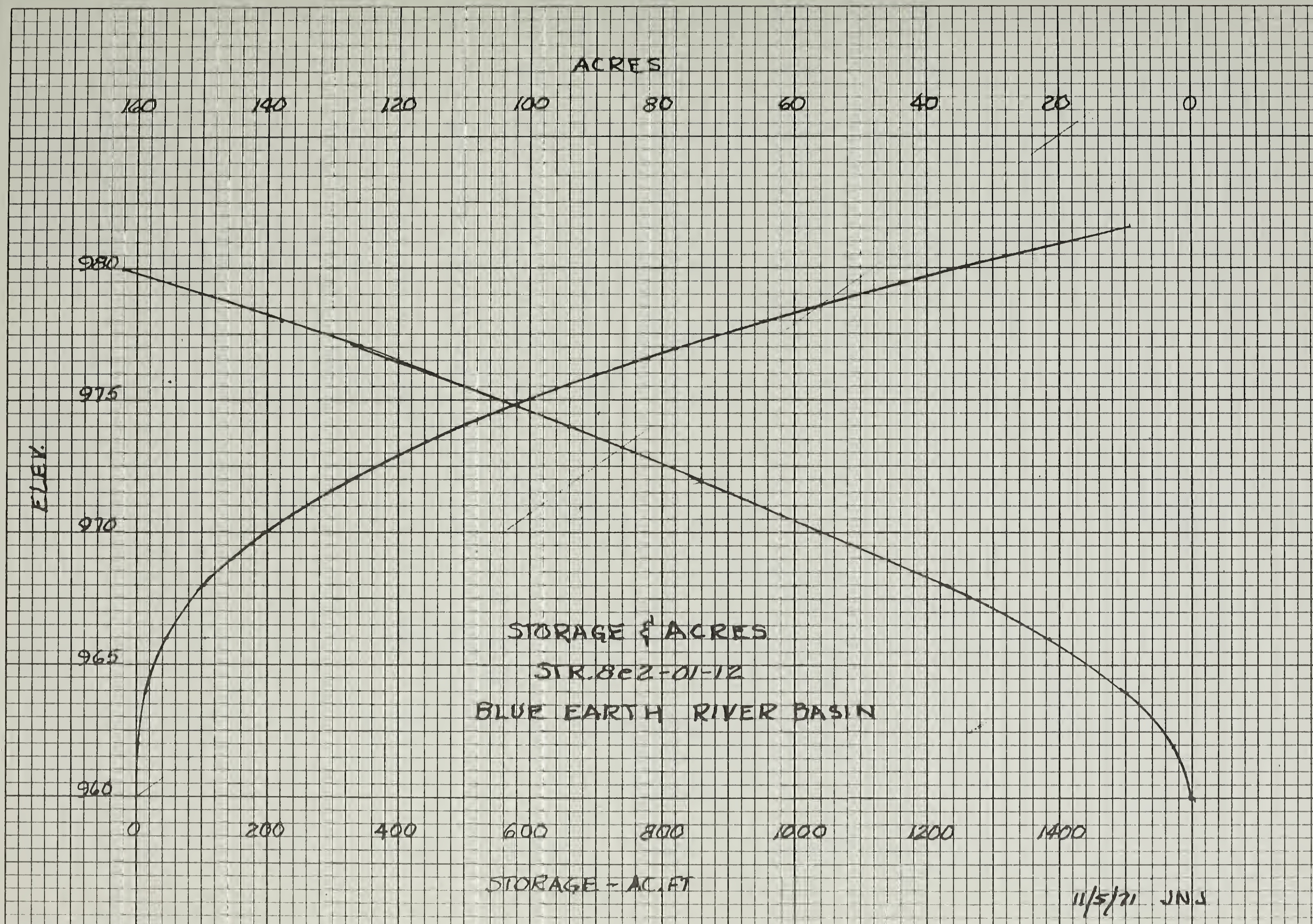


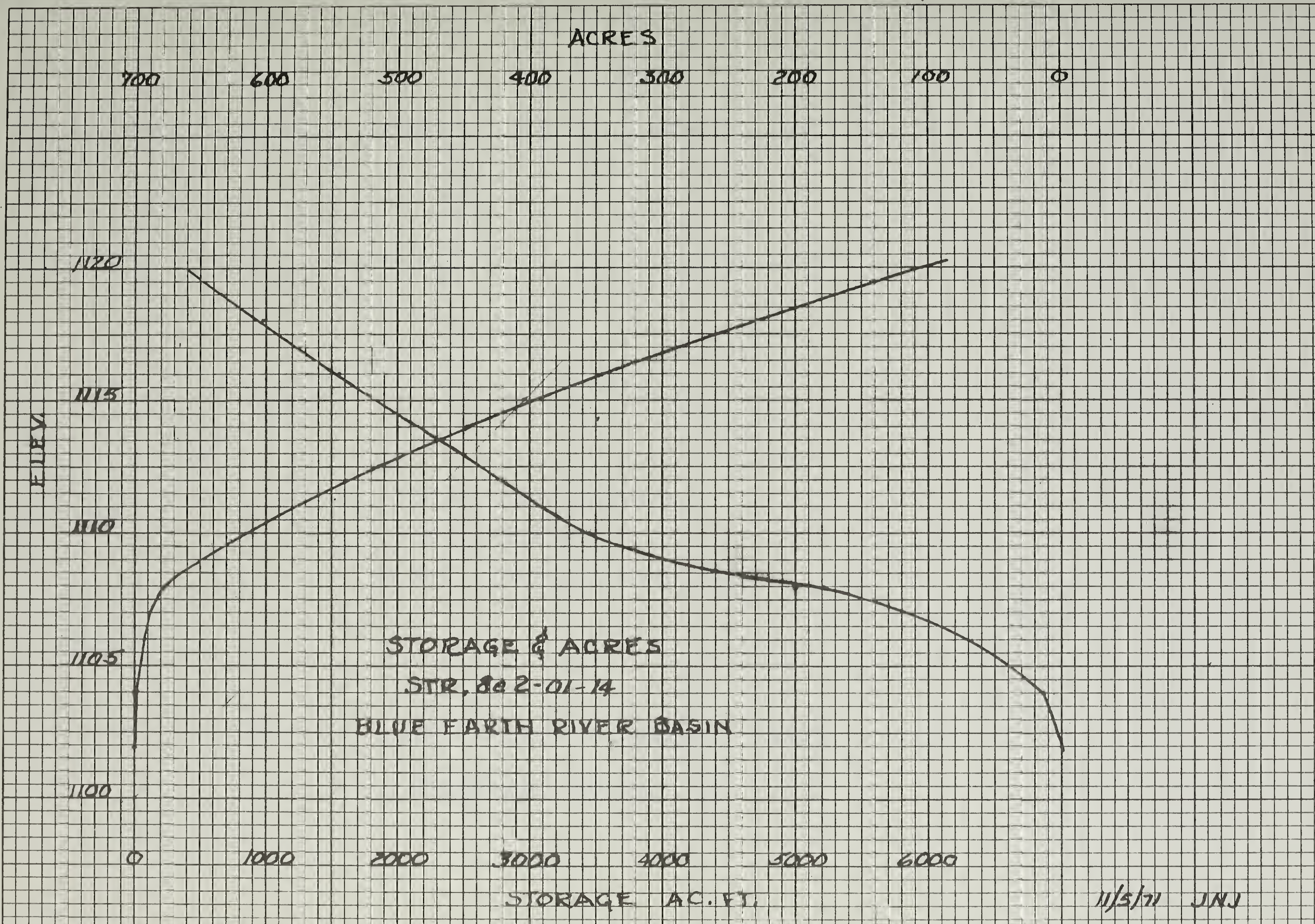
ACRES
800
700
600
500
400
300
200
100
0
1190
1180
1170
1160
1150
ELEV
STORAGE & ACRES
STR. 8e 2-01-1
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
7000
8000
AC. FT.

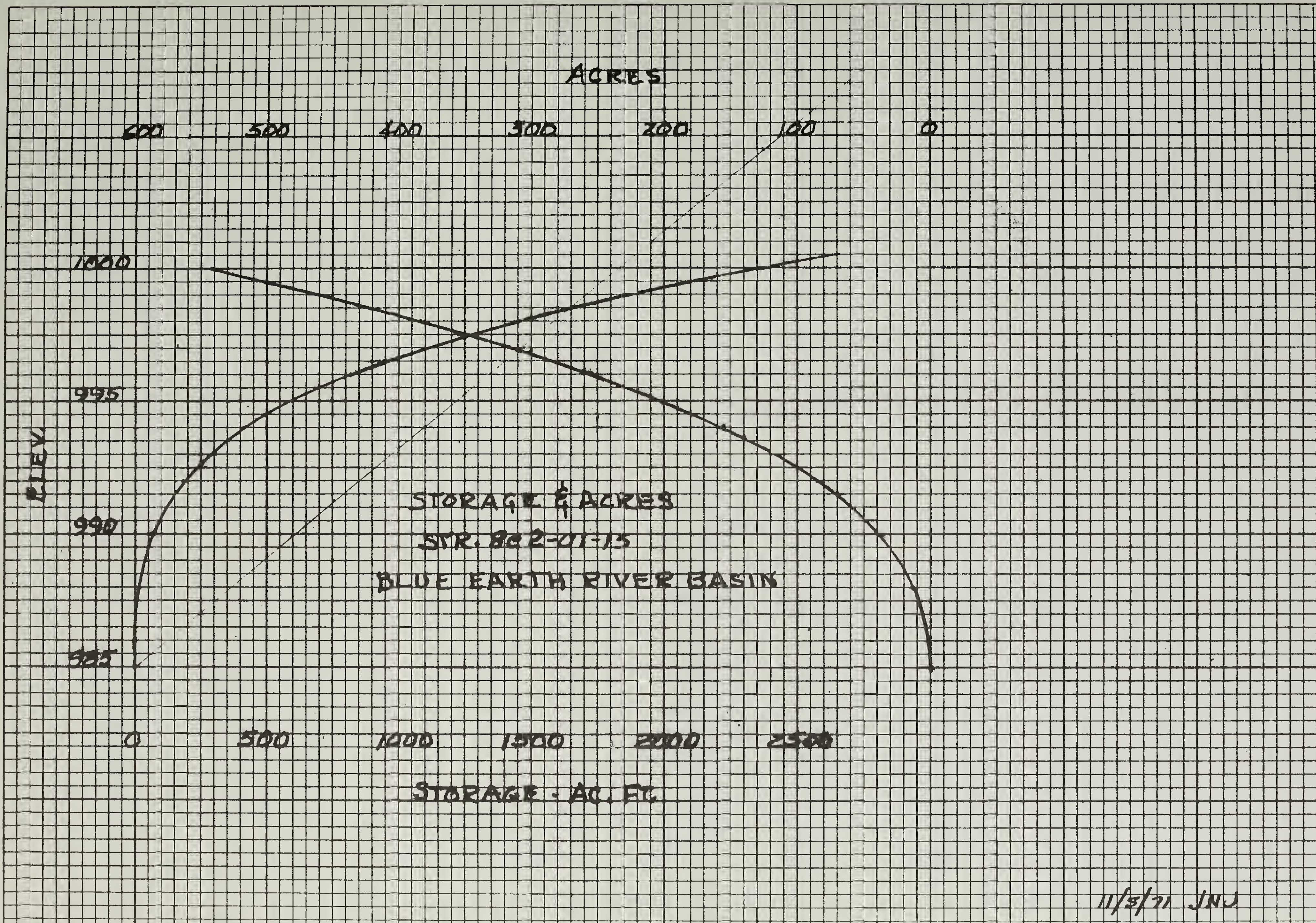

ACRES
900
800
700
600
500
400
300
200
100
0
995
990
985
980
975
970
ELEV.
STORAGE & ACRES
STR. 8e2-01-3
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
AC. FT.
10
8
4
2
0


ACRES
350
300
250
200
150
100
50
0
1008
1006
1004
1002
1000
998
ELEV.
STORAGE & ACRES
STR - 8e 2-01-10
BLUE EARTH RIVER BASIN
STORAGE - AC. FT.
0
200
400
600
800
1000
11/5/71 JNJ

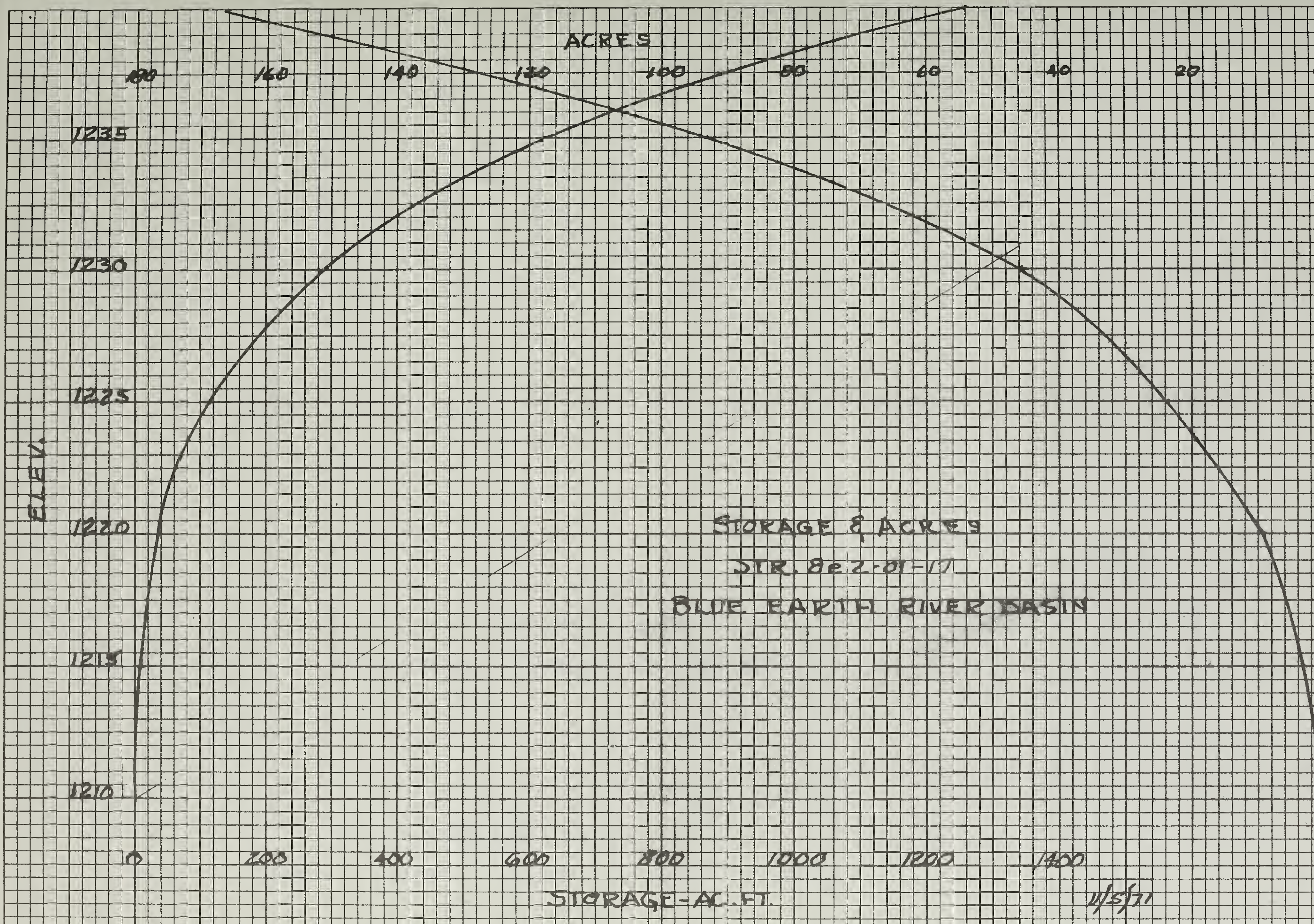

ACRES
500
400
300
200
100
0
990
985
980
975
970
Elev.
STORAGE & ACRES
STR. 8e2-01-11
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
STORAGE - AC. FT.
11/5/71 JNJ

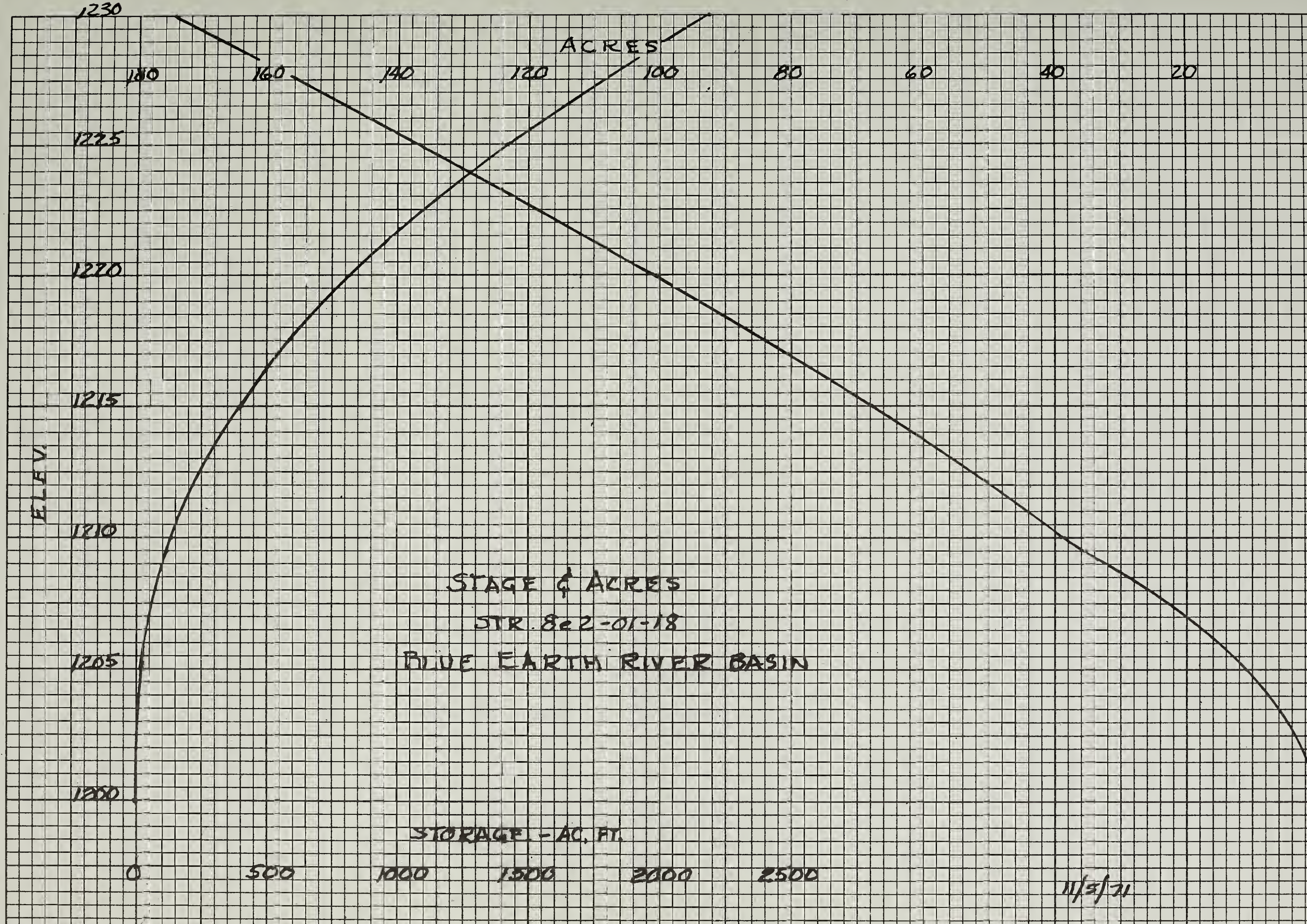

ACRES
160
140
120
100
80
60
40
20
0
ELEV.
980
975
970
965
960
STORAGE & ACRES
STR. 8e2-01-12
BLUE EARTH RIVER BASIN
0
200
400
600
800
1000
1200
1400
STORAGE - AC.FT
11/5/71 JNJ

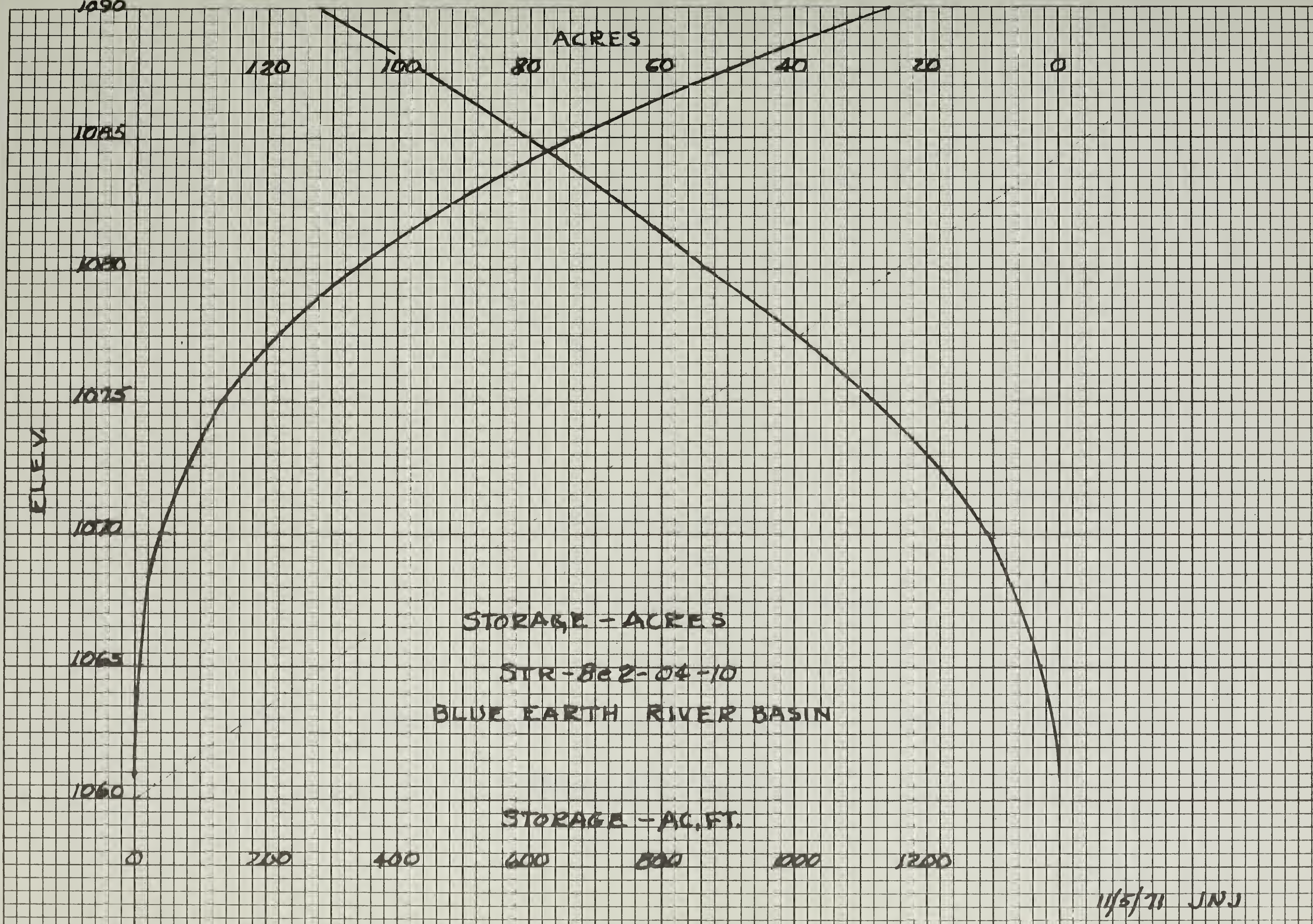

ACRES
700
600
500
400
300
200
100
0
ELEV.
1120
1115
1110
1105
1100
STORAGE & ACRES
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
STORAGE AC. FT.
11/5/71 JNJ

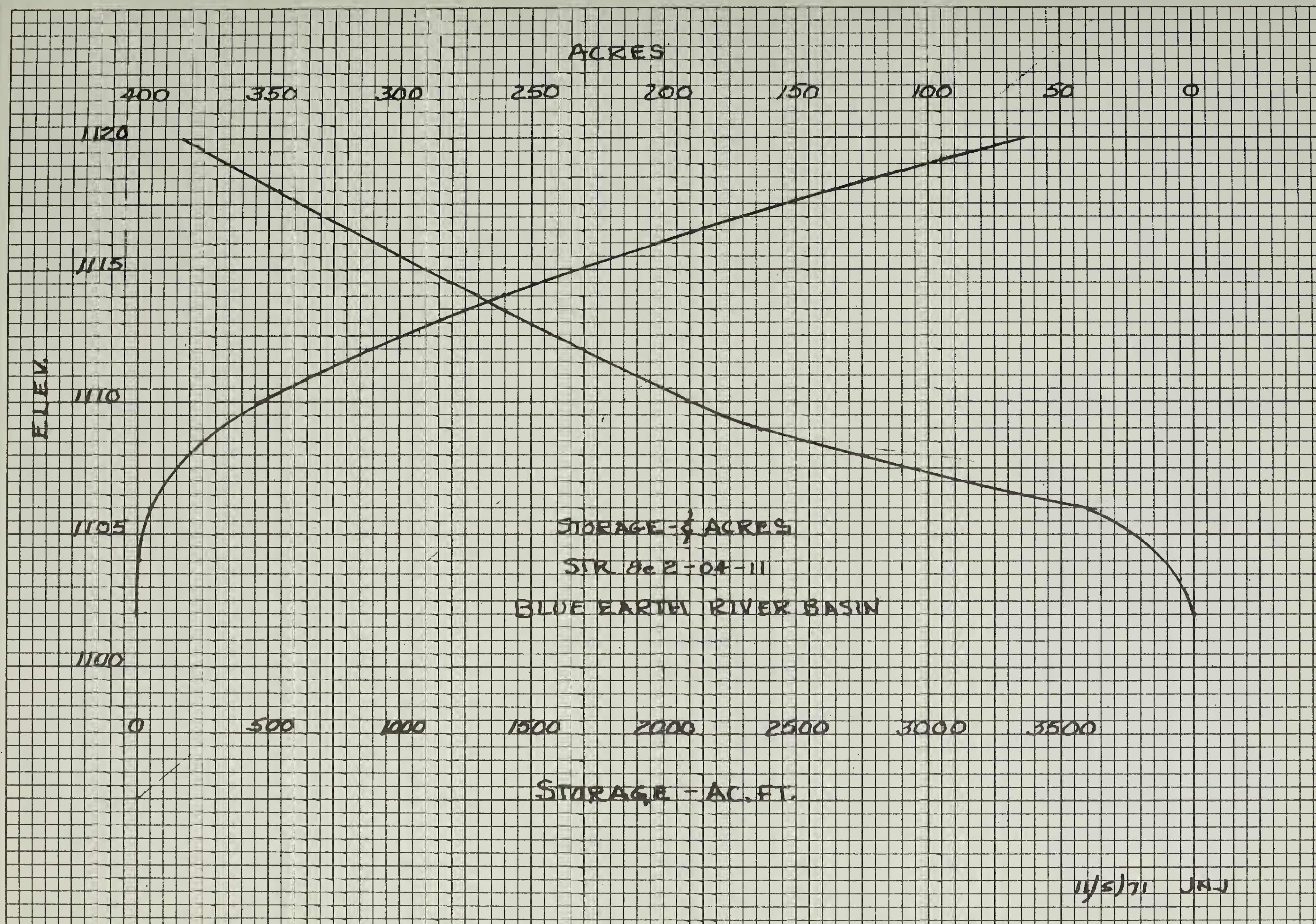


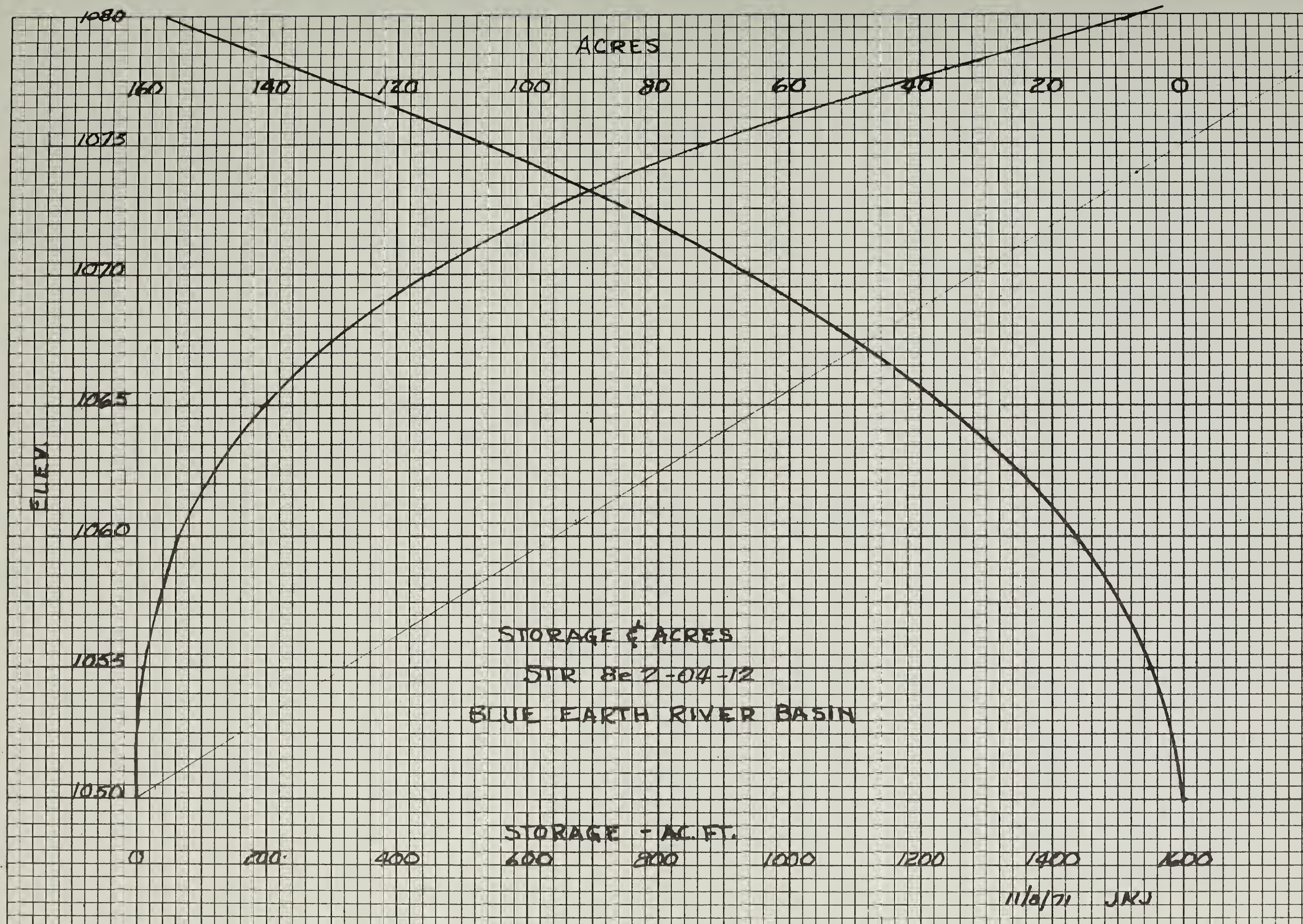
ACRES
600
500
400
300
200
100
0
ELEV.
1000
995
990
985
STORAGE & ACRES
STR. BC 2-01-15
BLUE EARTH RIVER BASIN
0
500
1000
1500
2000
2500
STORAGE - AC. FT.
11/3/71 JNJ

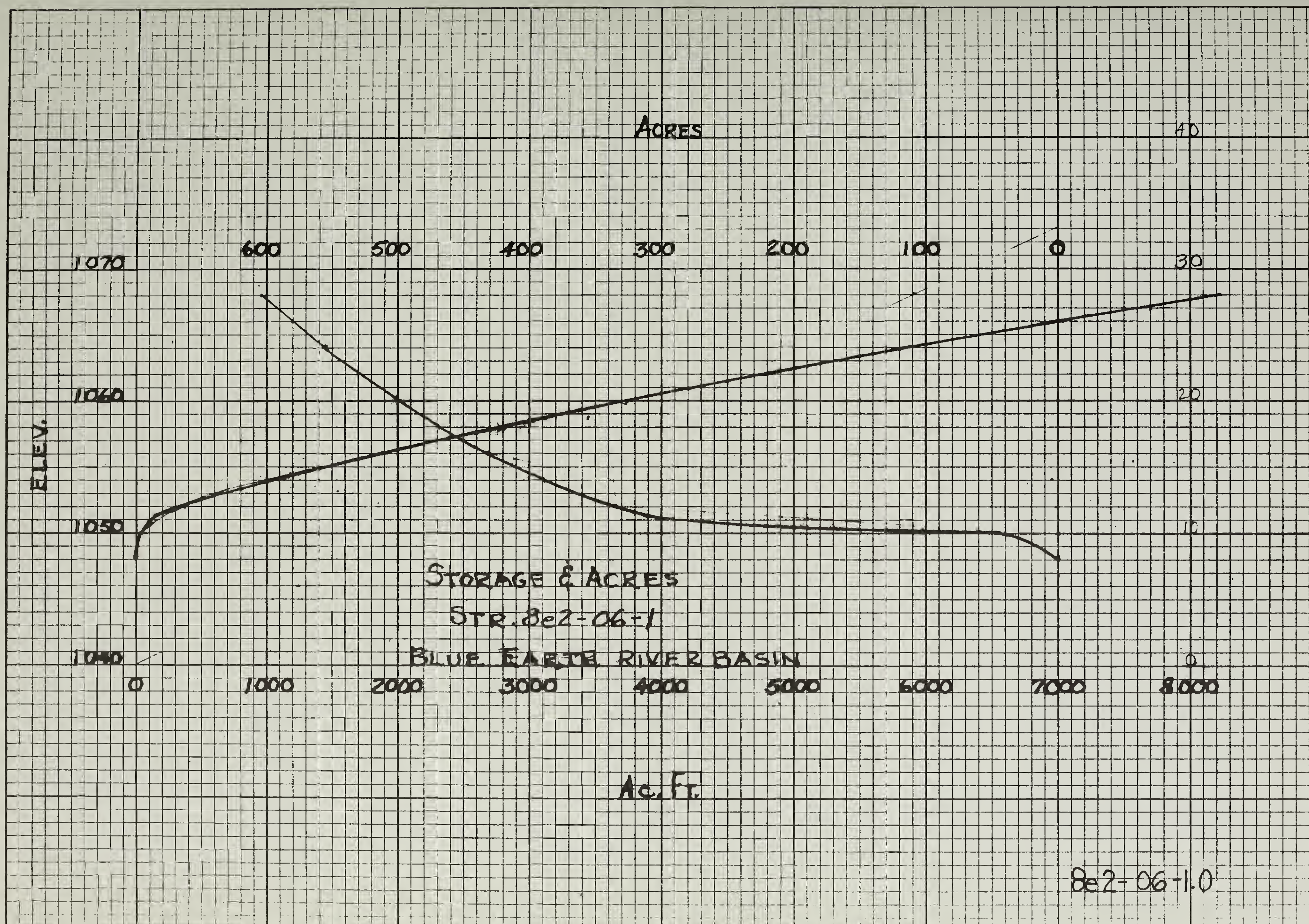

ACRES
180
160
140
120
100
80
60
40
20
0
1235
1230
1225
1220
1215
1210
ELEV.
STORAGE & ACRES
STR. 8e 2-01-17
BLUE EARTH RIVER BASIN
0
200
400
600
800
1000
1200
1400
STORAGE-AC. FT.
11/5/71


ACRES
180
160
140
120
100
80
60
40
20
0
1230
1225
1220
1215
1210
1205
1200
ELEV.
STAGE & ACRES
STR. 8e2-01-18
BLUE EARTH RIVER BASIN
STORAGE - AC. FT.
0
500
1000
1500
2000
2500
11/5/71

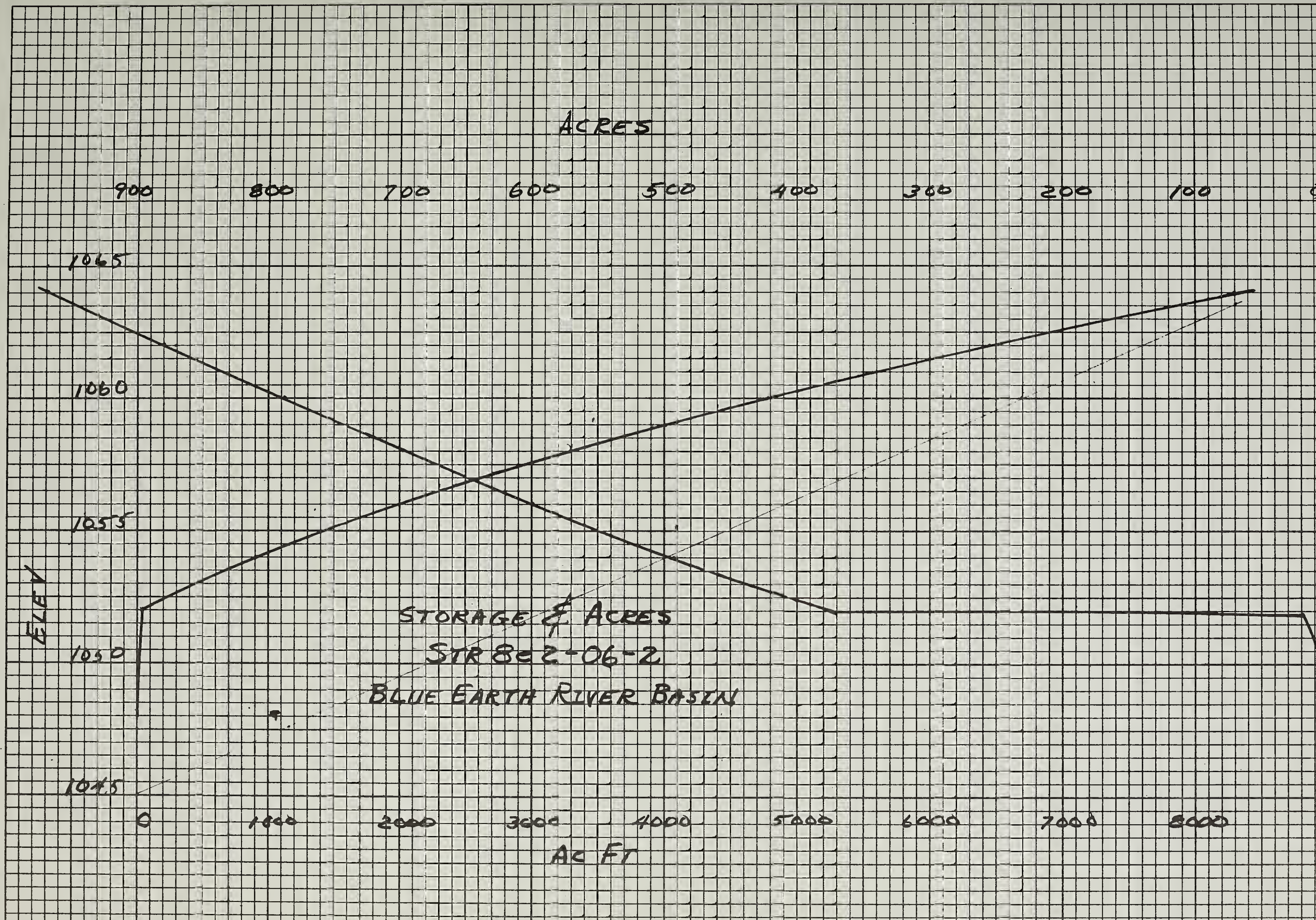

ACRES
120
100
80
60
40
20
0
1090
1085
1080
1075
1070
1065
1060
ELEV.
STORAGE - ACRES
STR-Be2-04-10
BLUE EARTH RIVER BASIN
STORAGE - AC.FT.
0
200
400
600
800
1000
1200
11/5/71 JNJ


ACRES
400
350
300
250
200
150
100
50
0
1120
1115
1110
1105
1100
ELEV.
STORAGE - & ACRES
STR. 8c 2-04-11
BLUE EARTH RIVER BASIN
0
500
1000
1500
2000
2500
3000
3500
STORAGE - AC. FT.
11/5/71 JHJ

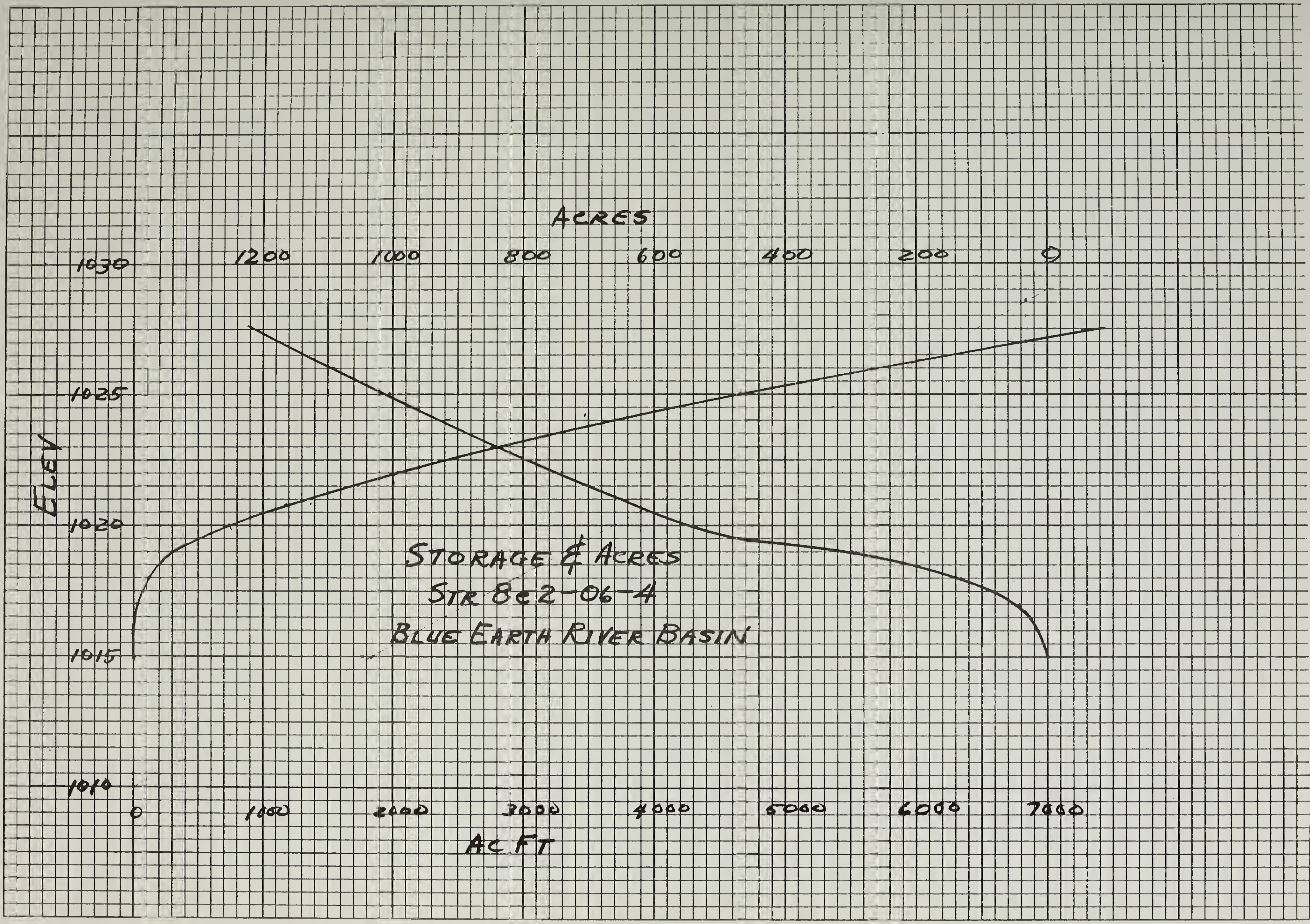

ACRES
160
140
120
100
80
60
40
20
0
1080
1075
1070
1065
1060
1055
1050
ELEV.
STORAGE & ACRES
STR 8e 2-04-12
BLUE EARTH RIVER BASIN
STORAGE - AC. FT.
0
200
400
600
800
1000
1200
1400
1600
11/8/71 JKJ



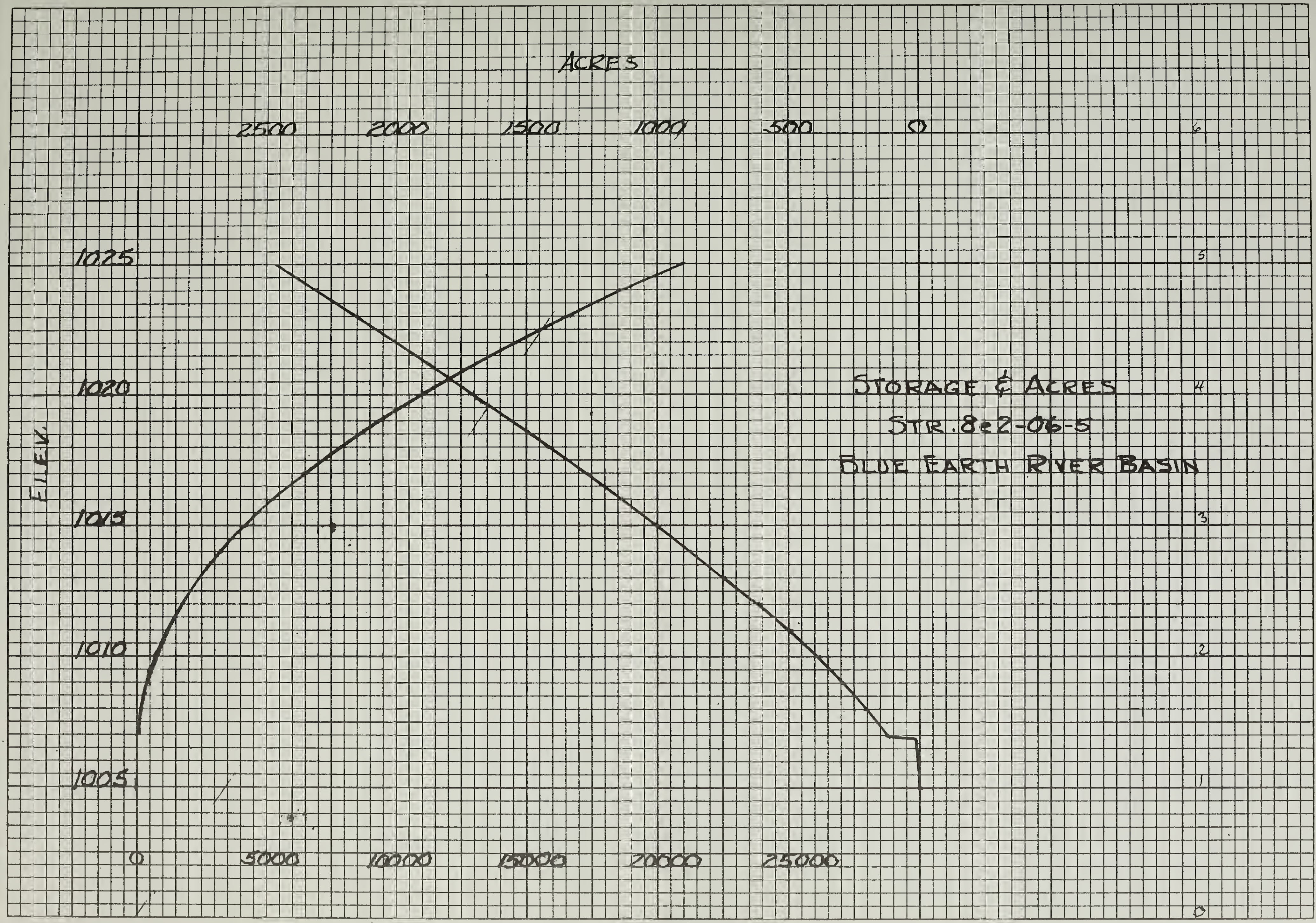
ACRES
600
500
400
300
200
100
0
40
30
20
10
0
1070
1060
1050
1040
ELEV.
STORAGE & ACRES
STR. 8e2-06-1
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
7000
8000
Ac. Ft.
8e2-06-1.0



ACRES
900
800
700
600
500
400
300
200
100
0
1065
1060
1055
1050
1045
ELEV
STORAGE & ACRES
STR 8e2-06-2
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
7000
8000
AC FT



ACRES
1200
1000
800
600
400
200
0
1030
1025
1020
1015
1010
ELEV
STORAGE & ACRES
STR 8e2-06-4
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
7000
AC FT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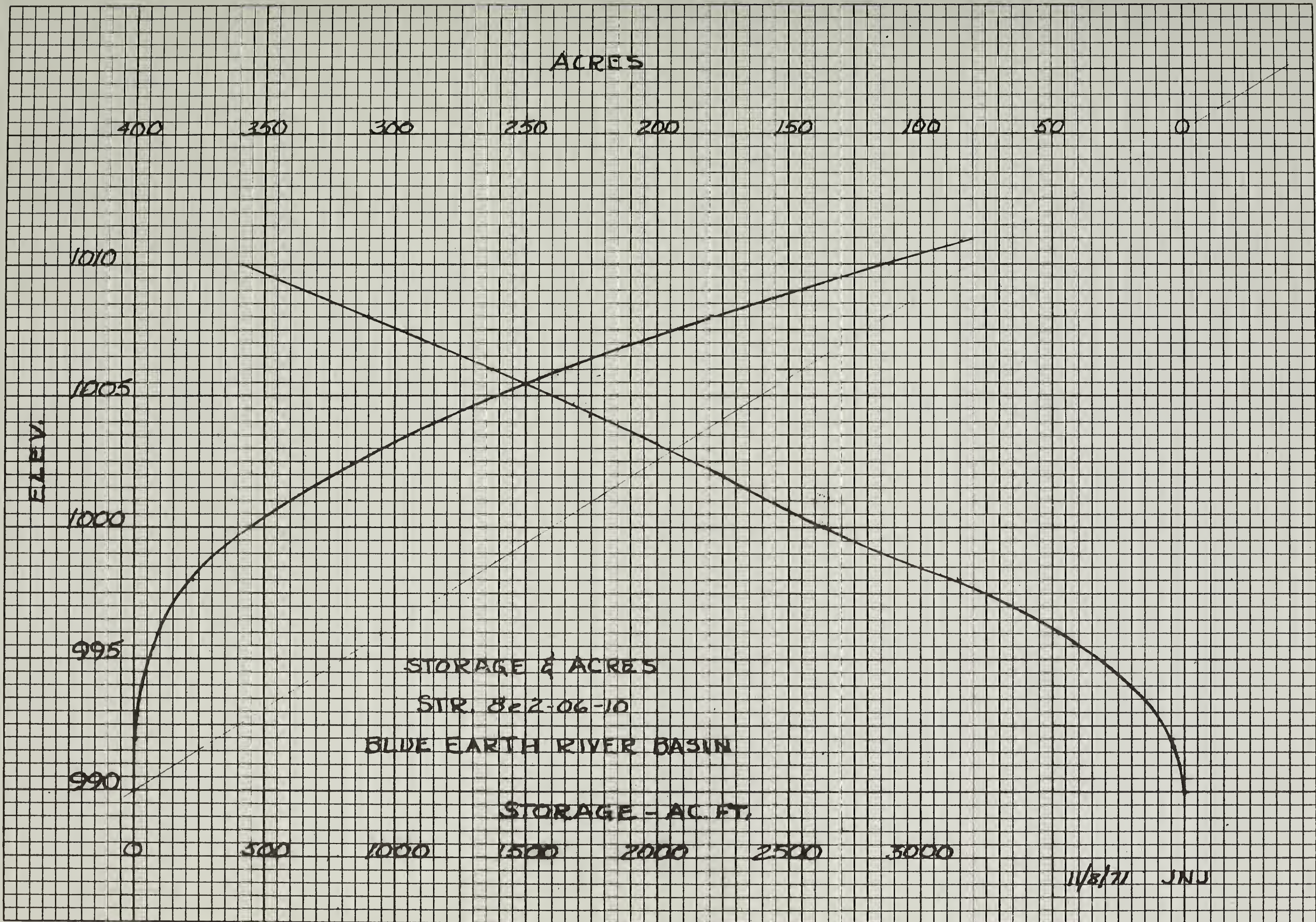
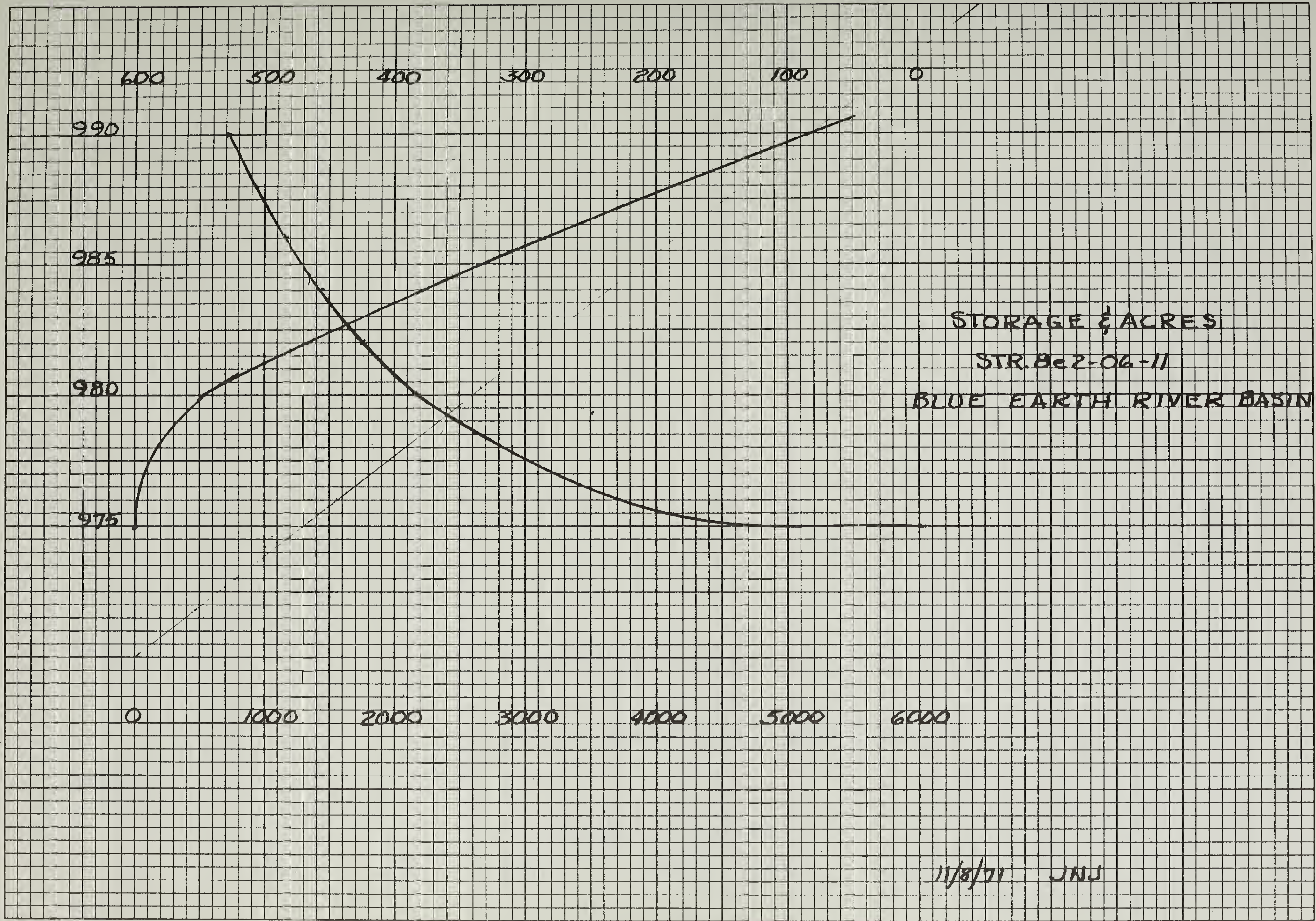
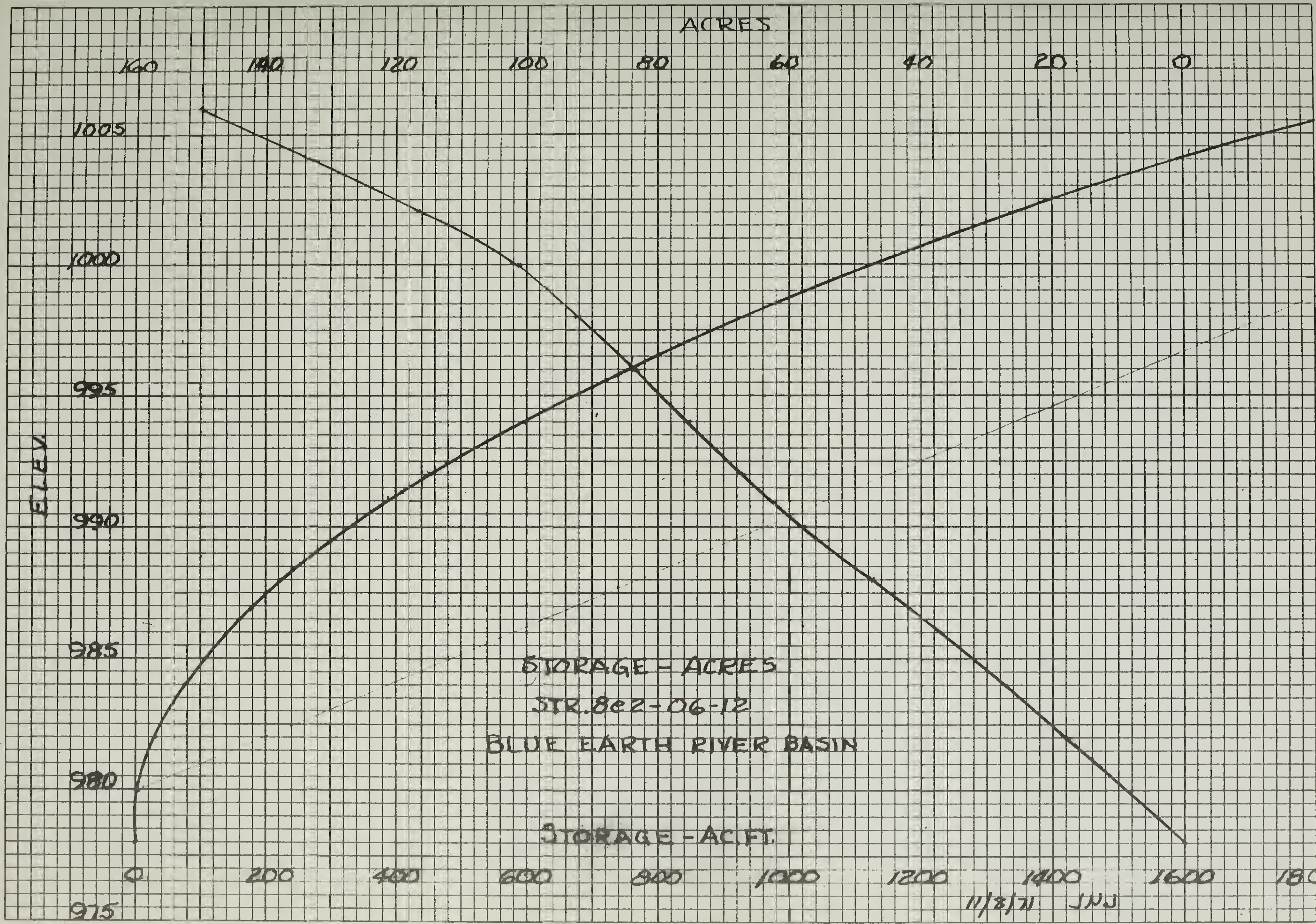
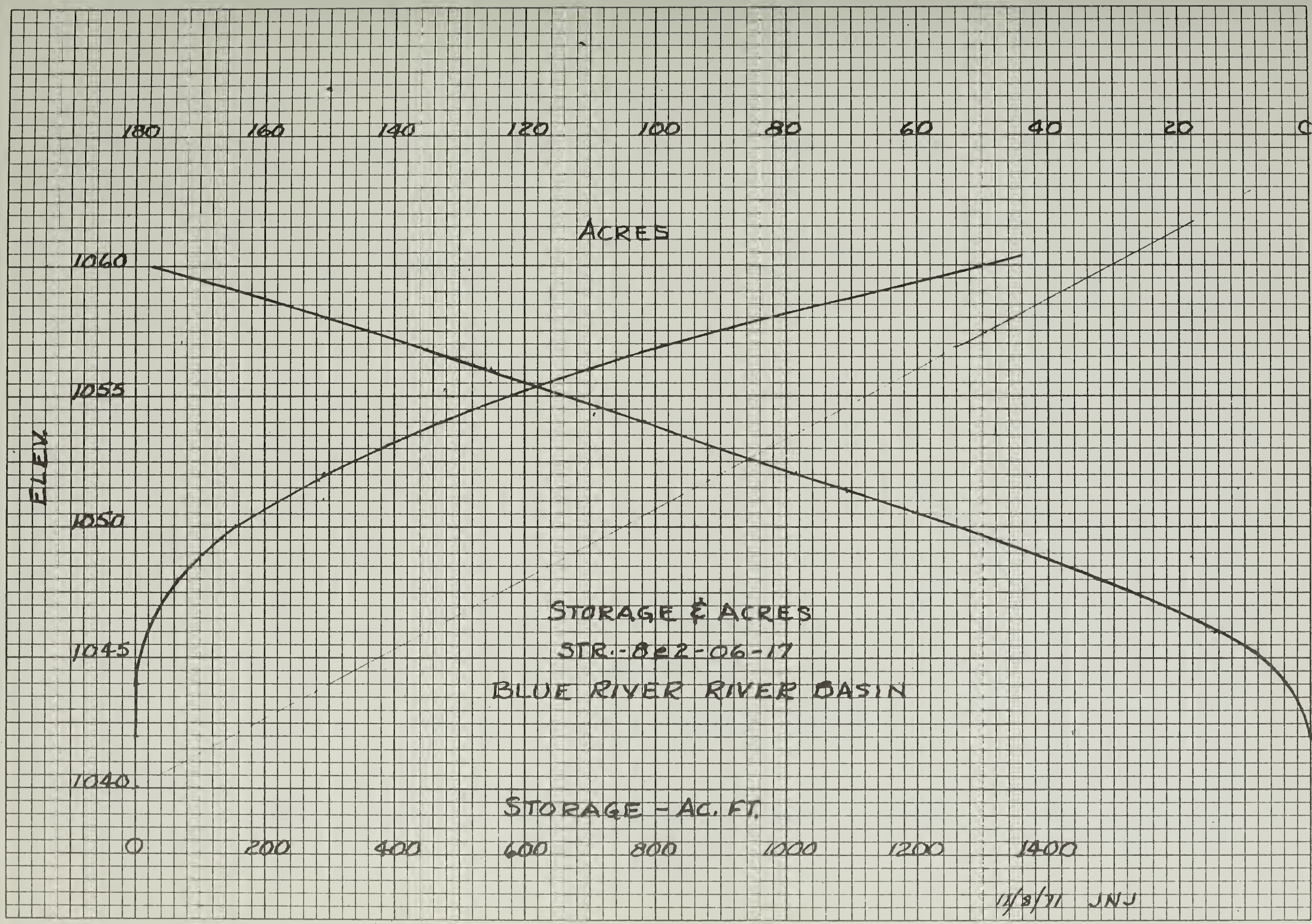
2500
2000
1500
1000
500
0
1025
1020
1015
1010
1005
ELEV.
0
5000
10000
15000
20000
25000
6
5
4
3
2
1
0
STORAGE & ACRES
STR. 8e2-06-5
BLUE EARTH RIVER BASIN


ACRES
400
350
300
250
200
150
100
50
0
ELEV.
1010
1005
1000
995
990
STORAGE & ACRES
STR. 8e2-06-10
BLUE EARTH RIVER BASIN
STORAGE - AC. FT.
0
500
1000
1500
2000
2500
3000
11/8/71 JNJ

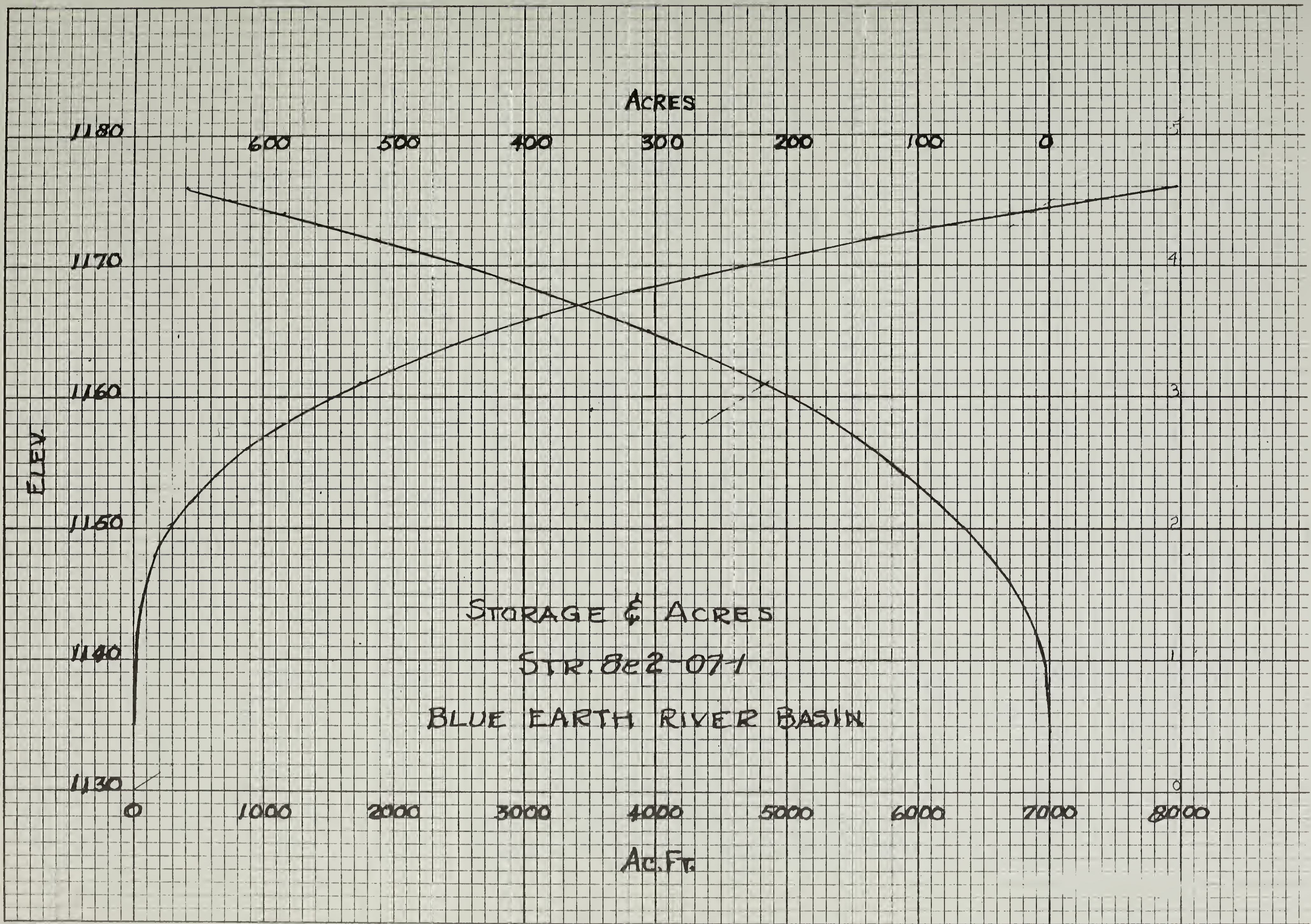


STORAGE & ACRES
STR. 8e2-06-11
BLUE EARTH RIVER BASIN
600
500
400
300
200
100
0
990
985
980
975
0
1000
2000
3000
4000
5000
6000
11/8/71 JNJ

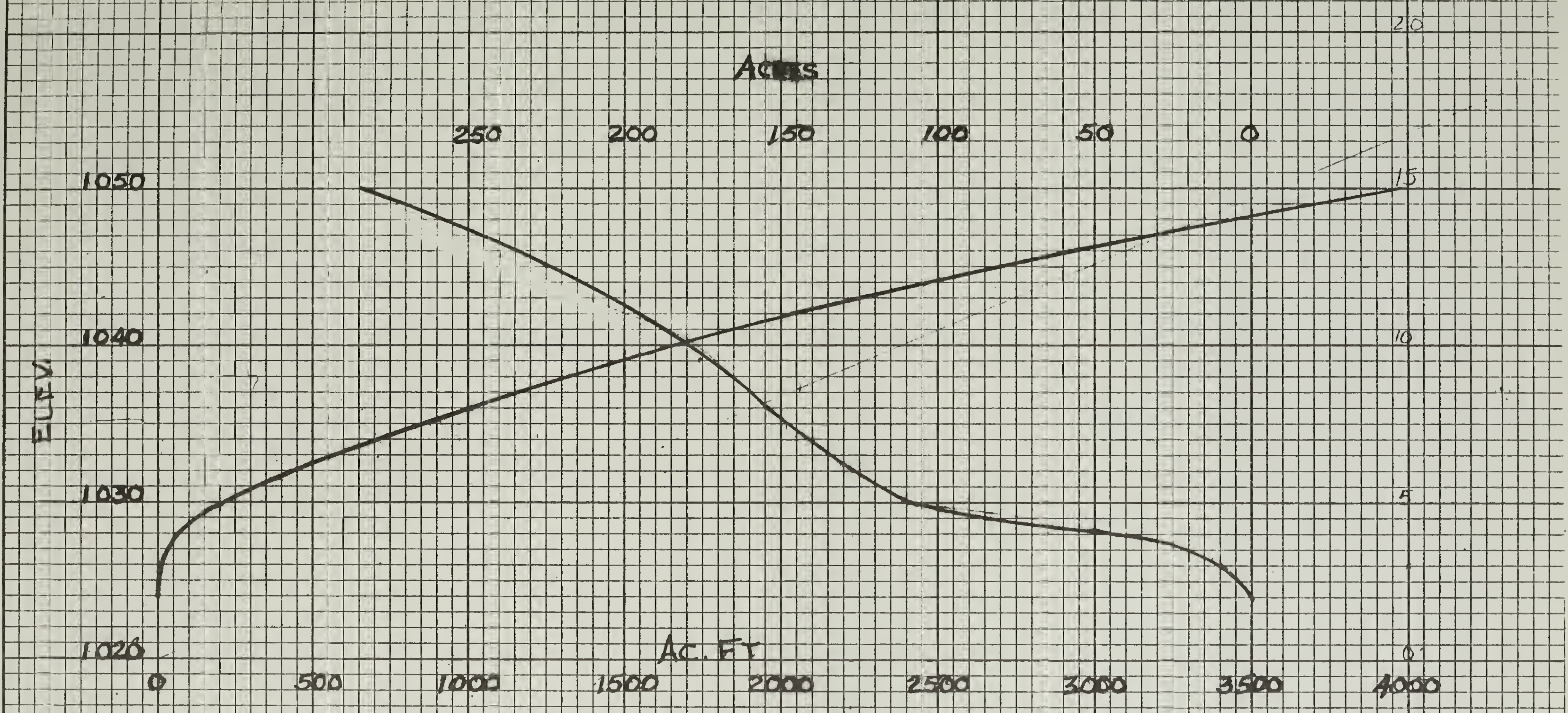

ACRES
160
140
120
100
80
60
40
20
0
1005
1000
995
990
985
980
975
ELEV.
STORAGE - ACRES
STR. 8e2-06-12
BLUE EARTH RIVER BASIN
STORAGE - AC.FT.
0
200
400
600
800
1000
1200
1400
1600
180
11/8/71 JNJ



180
160
140
120
100
80
60
40
20
0
ACRES
1060
1055
1050
1045
1040
ELEV.
STORAGE & ACRES
STR.-8e2-06-17
BLUE RIVER RIVER BASIN
STORAGE - AC. FT.
0
200
400
600
800
1000
1200
1400
11/8/71 JNJ



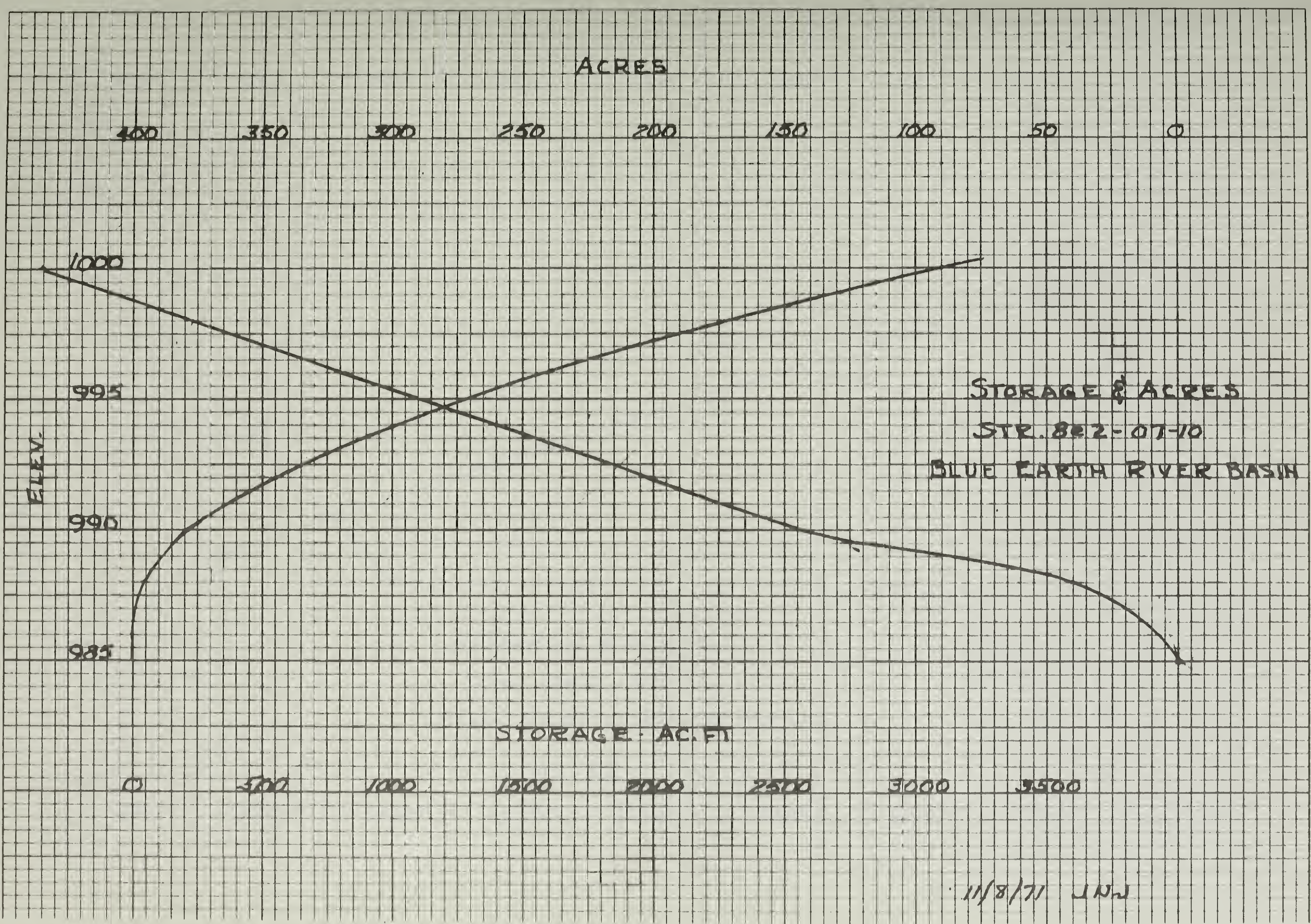
ACRES
600
500
400
300
200
100
0
1180
1170
1160
1150
1140
1130
ELEV.
5
4
3
2
1
0
STORAGE & ACRES
STR. 8e2-07-1
BLUE EARTH RIVER BASIN
0
1000
2000
3000
4000
5000
6000
7000
8000
AC. FT.

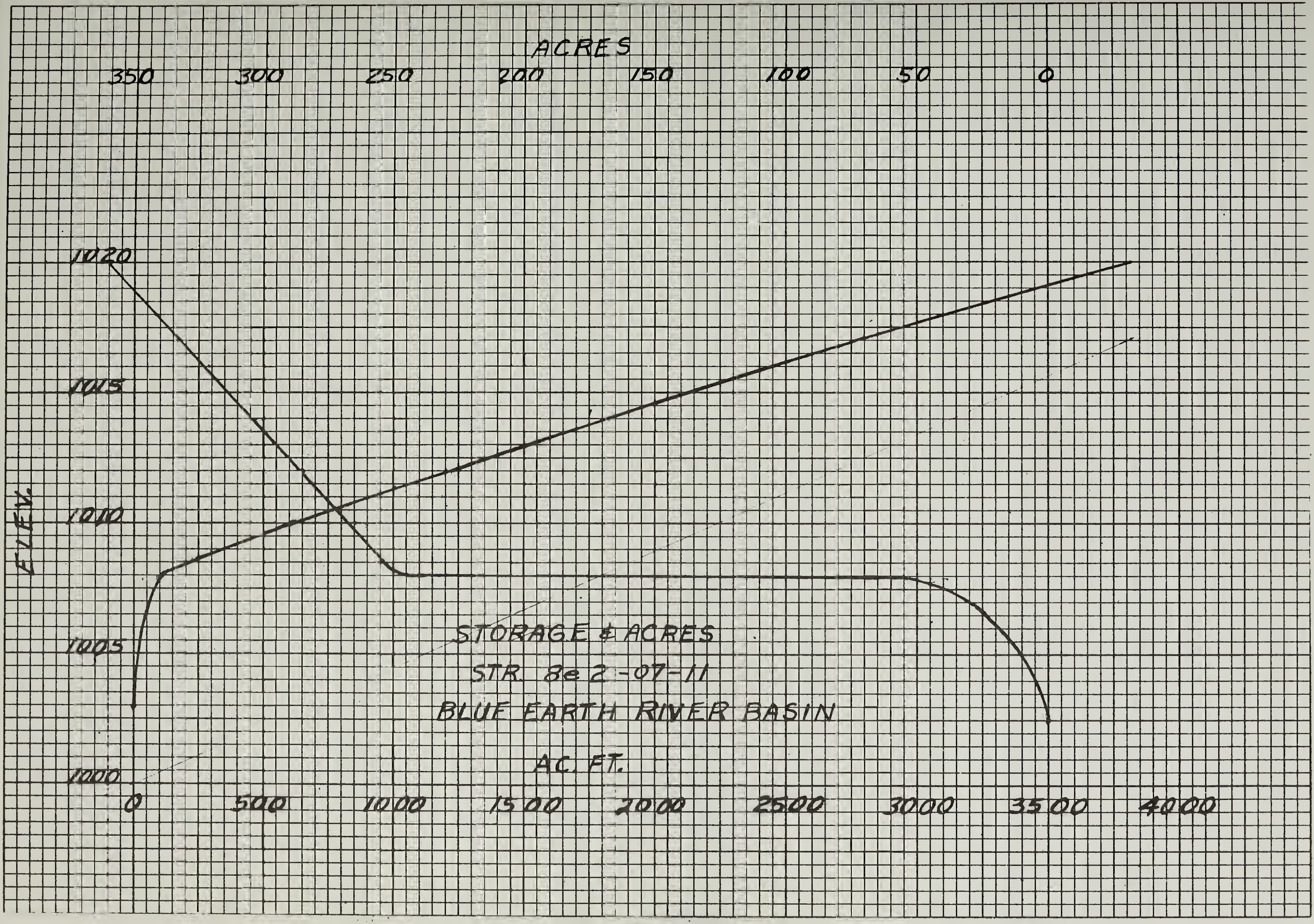


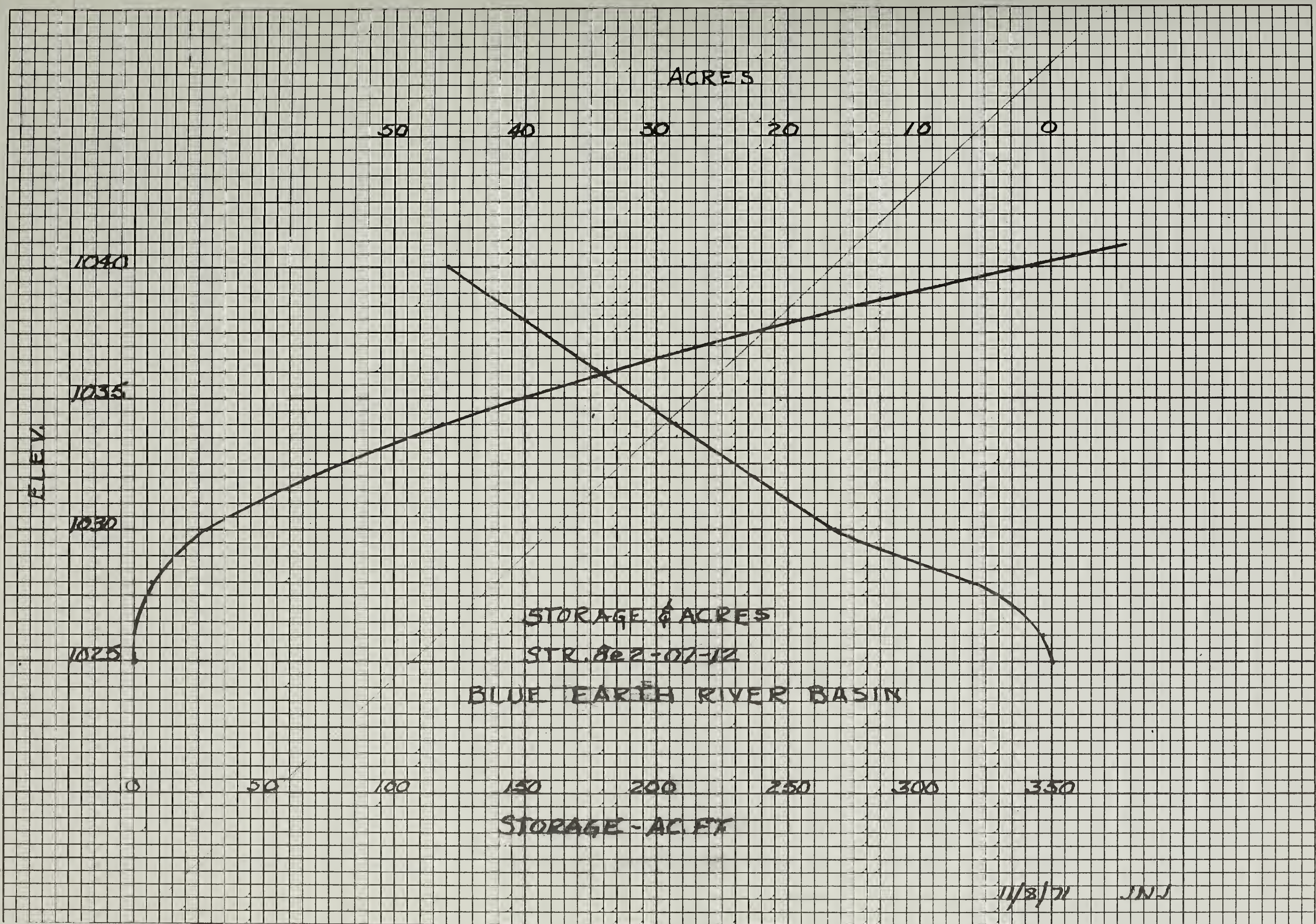
Storage & Acres

Str. 8e2-07-3

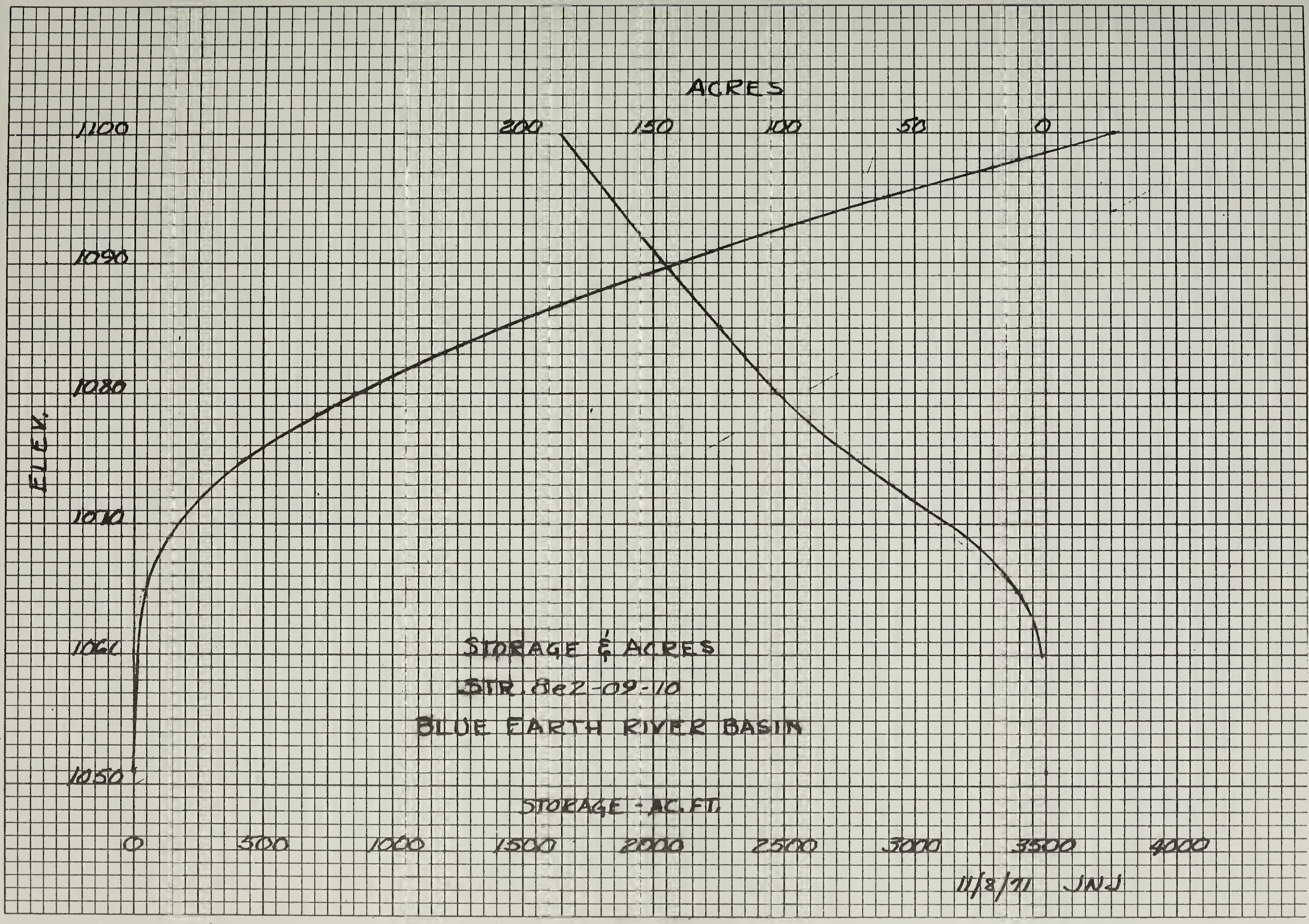
Blue Earth River Basin

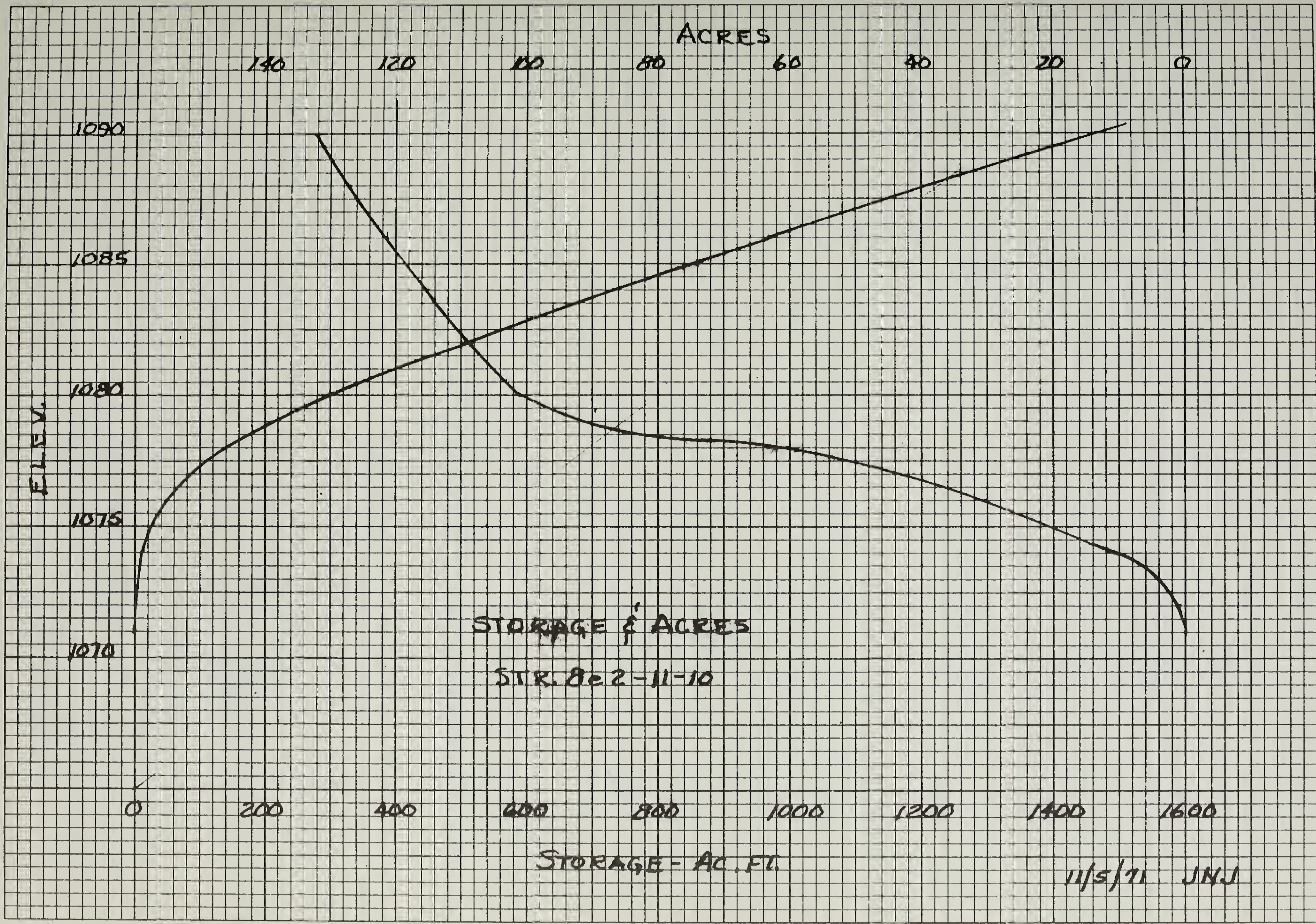

ACRES
400
350
300
250
200
150
100
50
0
1000
995
990
985
ELEV.
STORAGE & ACRES
STR. 8E2-07-10
BLUE EARTH RIVER BASIN
STORAGE AC. FT
0
500
1000
1500
2000
2500
3000
3500
11/8/71 JNJ

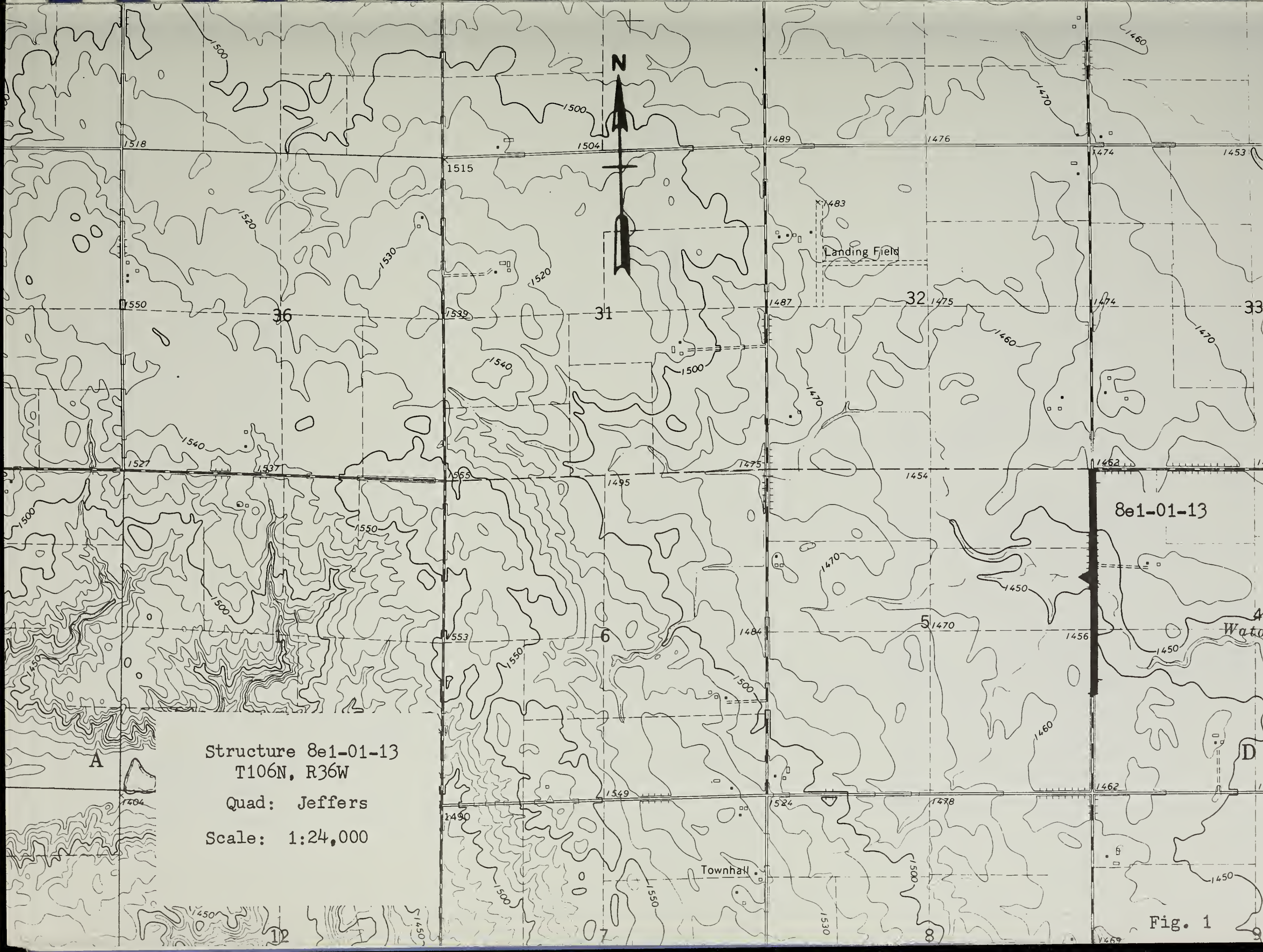

ACRES
350
300
250
200
150
100
50
0
ELEV.
1020
1015
1010
1005
1000
STORAGE & ACRES
STR. 8e 2-07-11
BLUE EARTH RIVER BASIN
AC. FT.
0
500
1000
1500
2000
2500
3000
3500
4000



ACRES
50
40
30
20
10
0
1040
1035
1030
1025
ELEV.
STORAGE & ACRES
STR. 8e2-07-12
BLUE EARTH RIVER BASIN
0
50
100
150
200
250
300
350
STORAGE - AC.FT.
11/8/71 JNJ

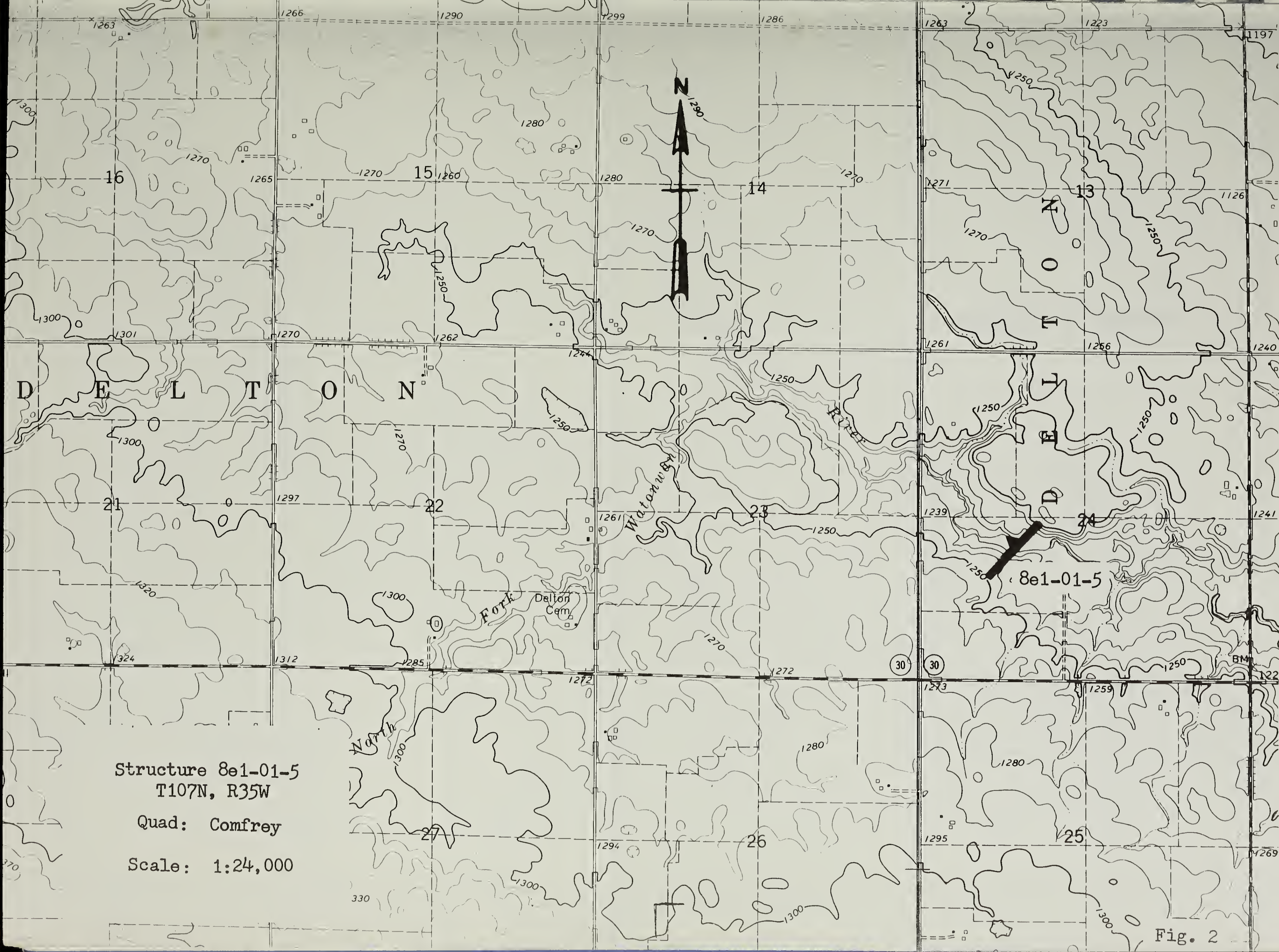

ACRES
200
150
100
50
0
1100
1090
1080
1070
1060
1050
ELEV.
STORAGE & ACRES
STR. 8e2-09-10
BLUE EARTH RIVER BASIN
STORAGE - AC. FT.
0
500
1000
1500
2000
2500
3000
3500
4000
11/8/71 JNJ


ACRES
140
120
100
80
60
40
20
0
1090
1085
1080
1075
1070
ELEV.
STORAGE & ACRES
STR. 8e2-11-10
0
200
400
600
800
1000
1200
1400
1600
STORAGE - AC. FT.
11/5/71 JNJ



N
Structure 8e1-01-13
T106N, R36W
Quad: Jeffers
Scale: 1:24,000
8e1-01-13
Landing Field
Townhall
A
D
36
31
32
33
1
6
5
4
12
7
8
9
1518
1515
1504
1489
1476
1474
1453
1483
1550
1539
1487
1475
1527
1537
1555
1495
1454
1462
1553
1484
1456
1490
1549
1524
1478
1404
1500
1520
1530
1540
1470
1460
1450
1550
Wato

Fig. 1



Structure 8e1-01-5
T107N, R35W

Quad: Comfrey

Scale: 1:24,000

Fig. 2

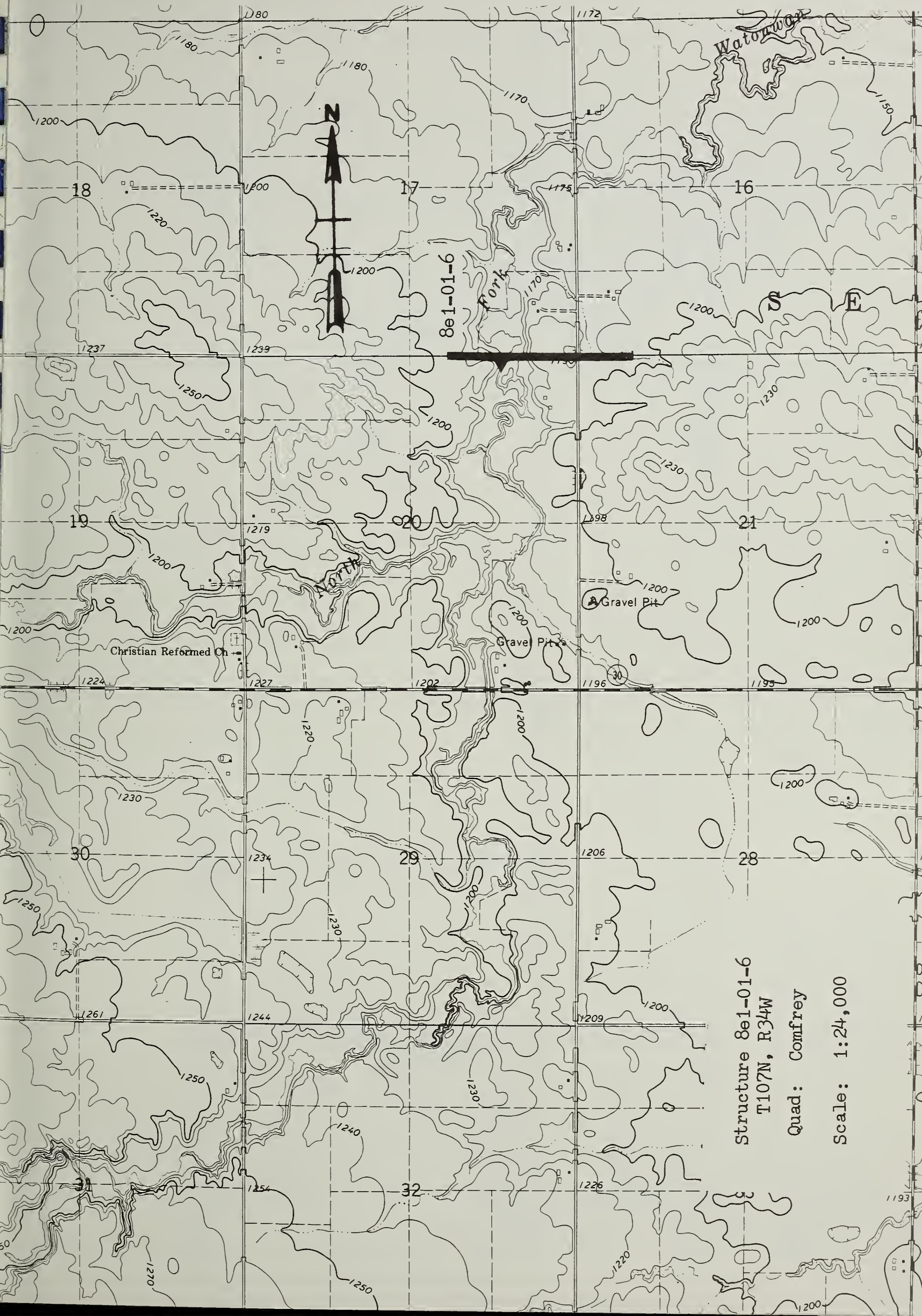


Fig. 3

Structure 8e1-01-6
T107N, R34W
Quad: Comfrey
Scale: 1:24,000

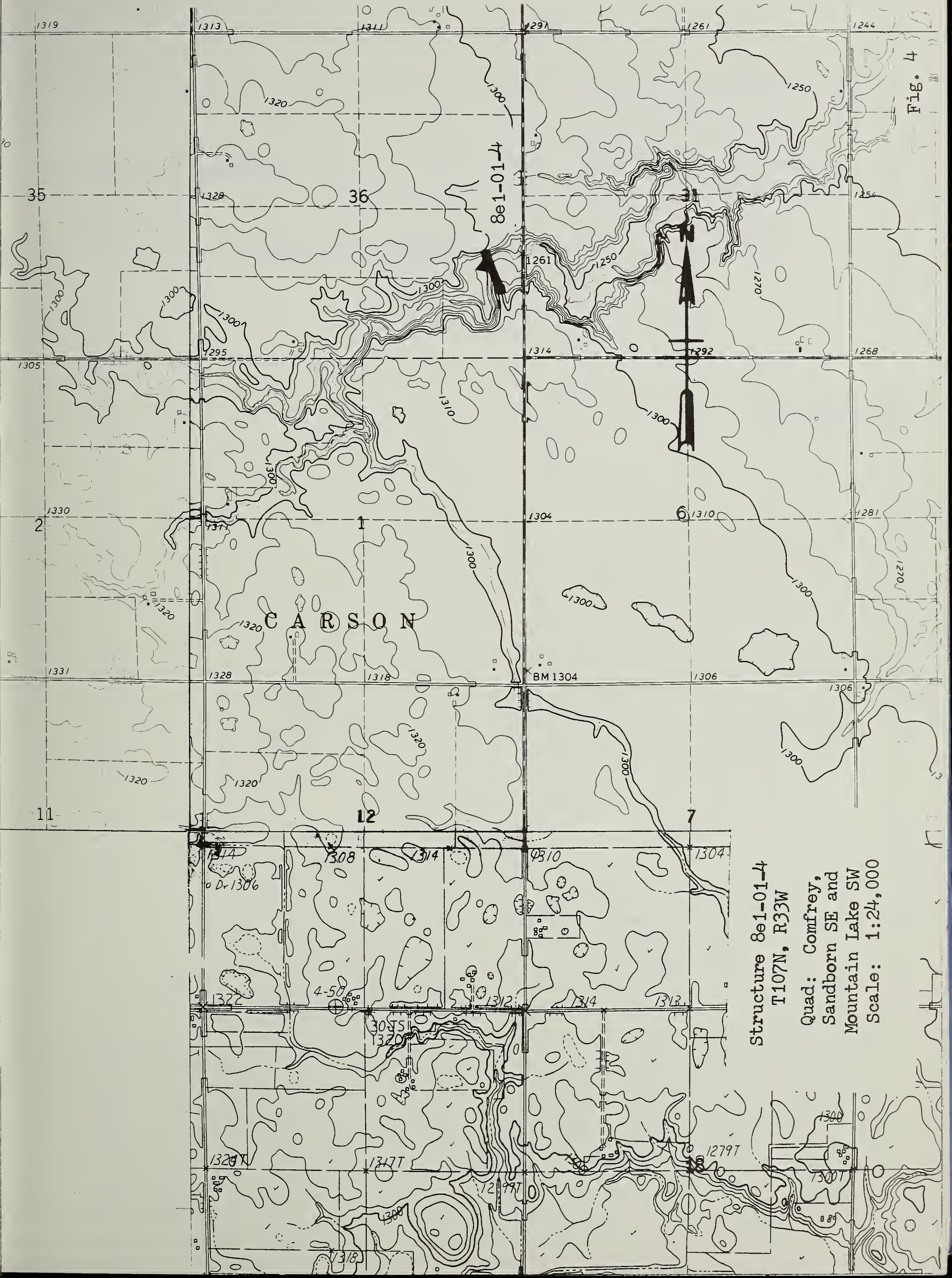
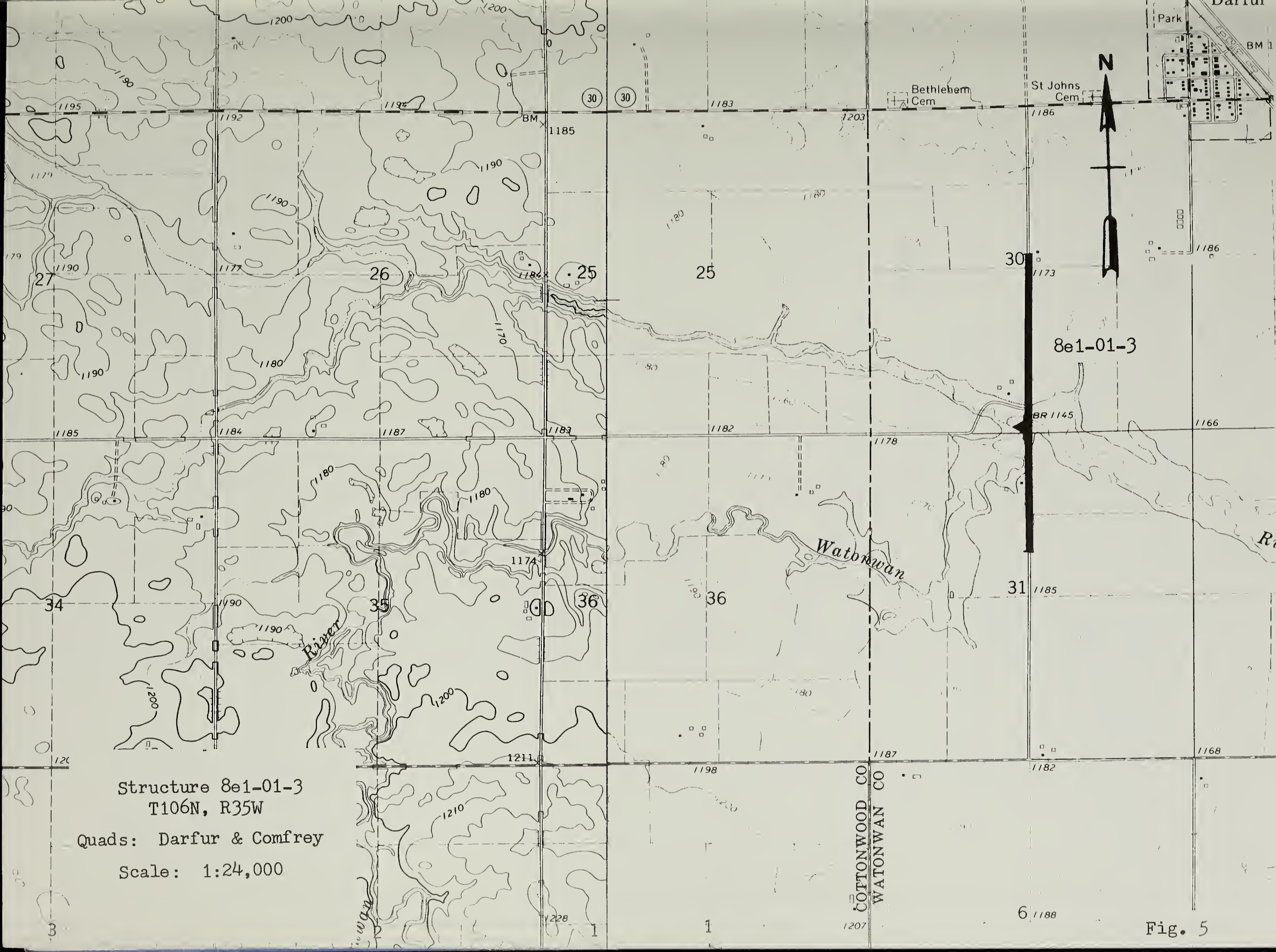


Fig. 4

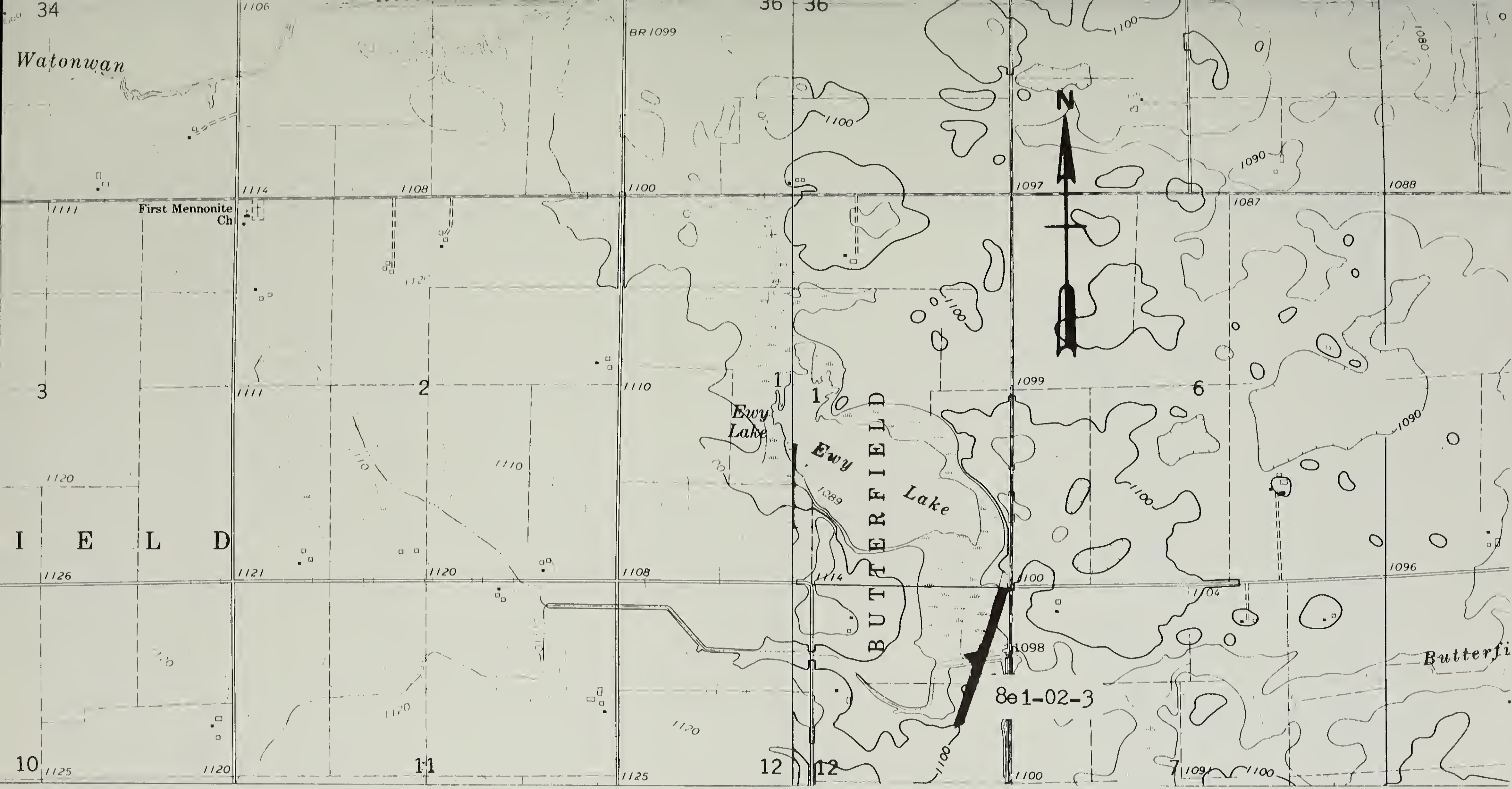
Structure 8e1-01-4
T107N, R33W

Quad: Comfrey,
Sandborn SE and
Mountain Lake SW
Scale: 1:24,000



Structure 8e1-01-3
T106N, R35W
Quads: Darfur & Comfrey
Scale: 1:24,000

Fig. 5



Structure 8e1-02-3

T106N, R33W

Quads: Godahl and Darfur

Scale 1:24,000

Fig. 6

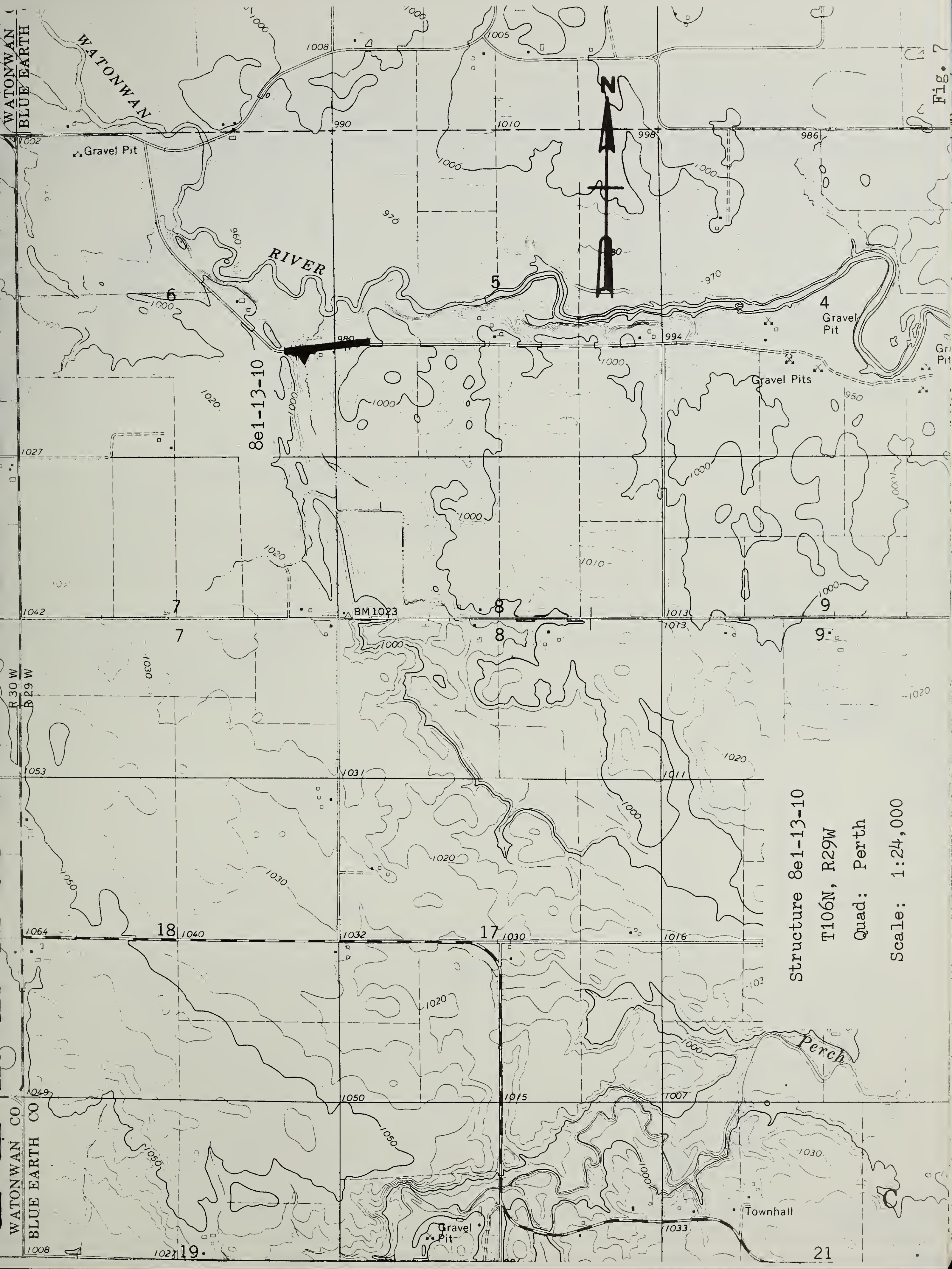


Fig. 7

Structure 8e1-13-10
T106N, R29W
Quad: Perth
Scale: 1:24,000

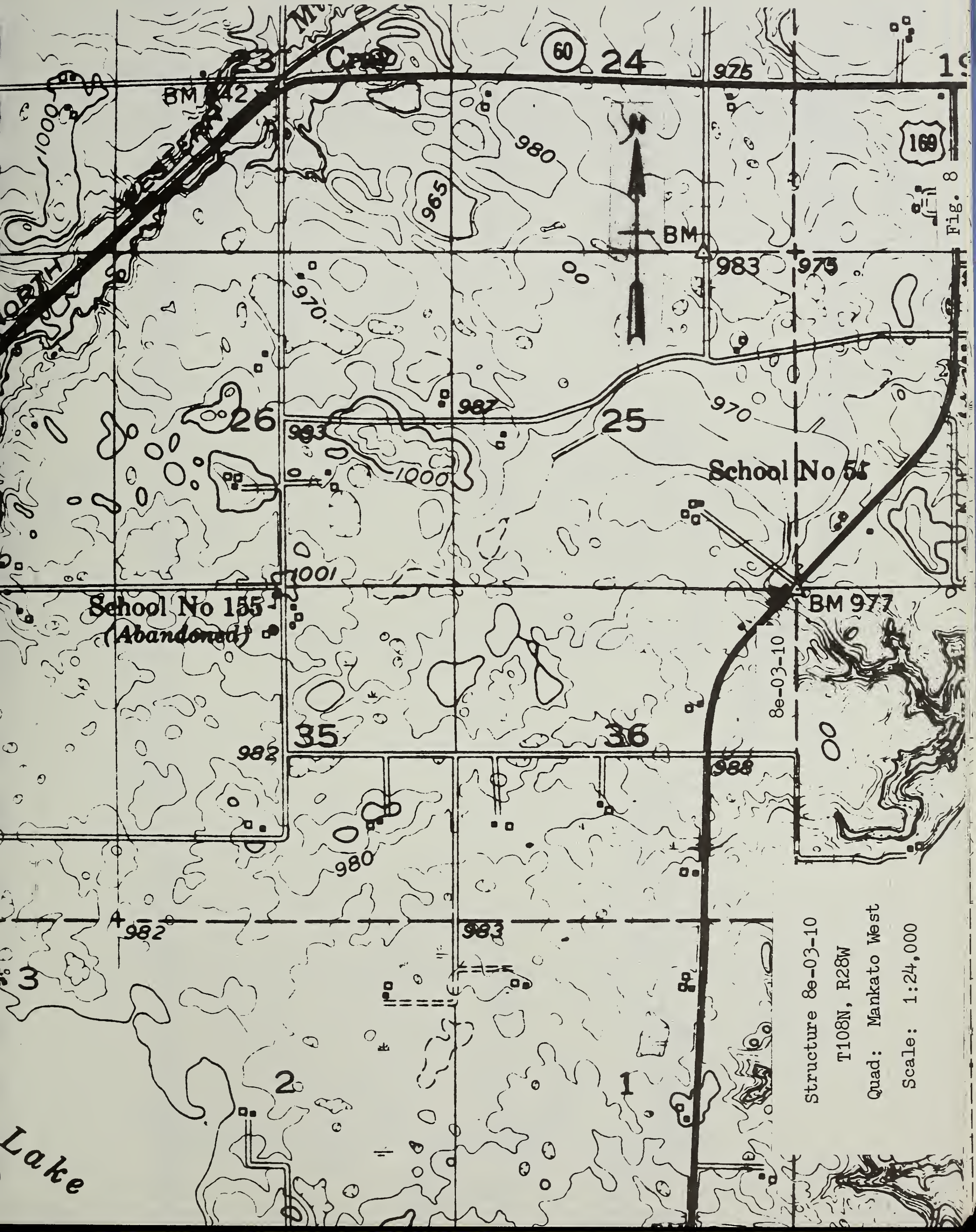
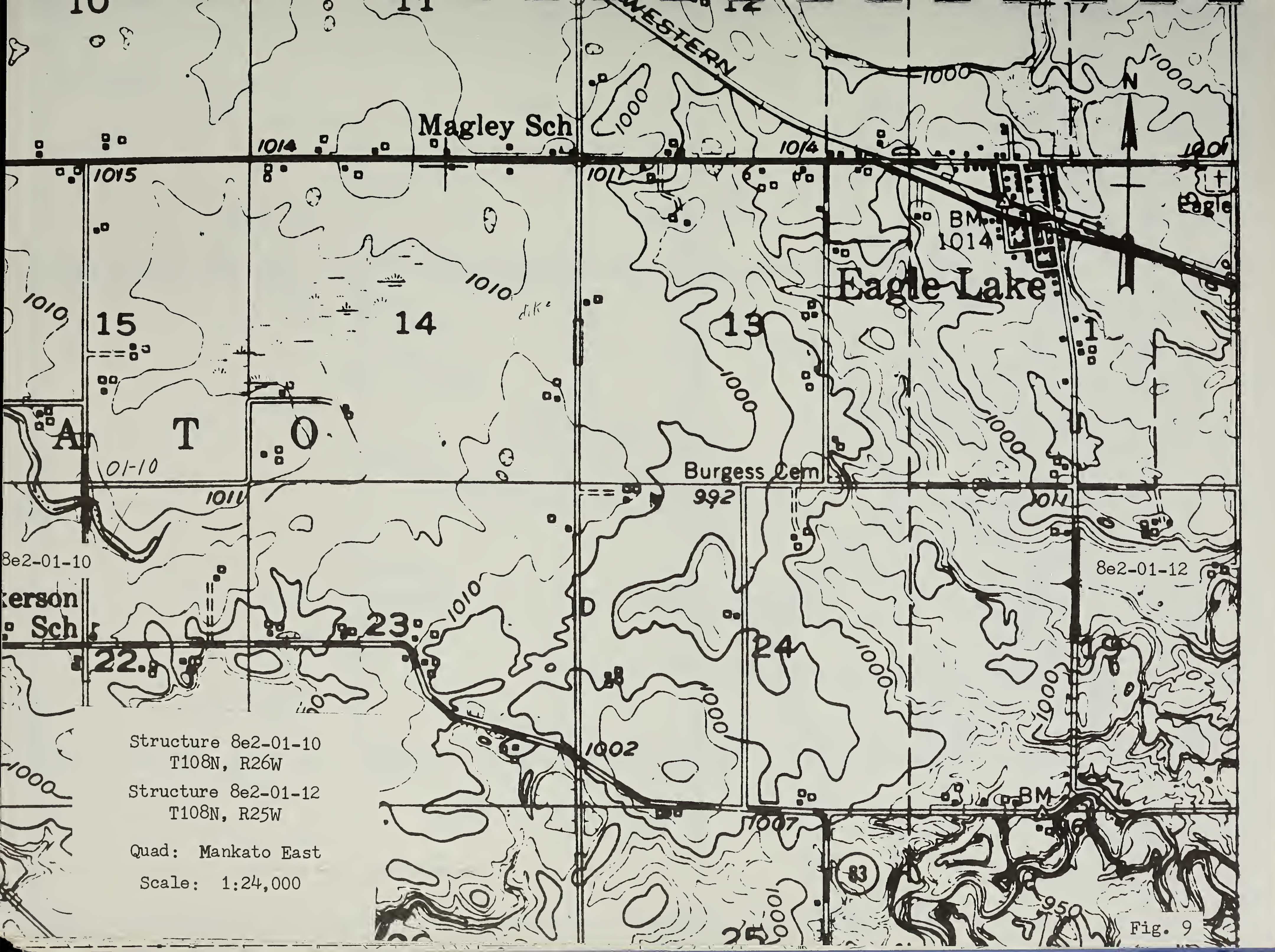


Fig. 8

Structure 8e-03-10
T108N, R28W
Quad: Mankato West
Scale: 1:24,000



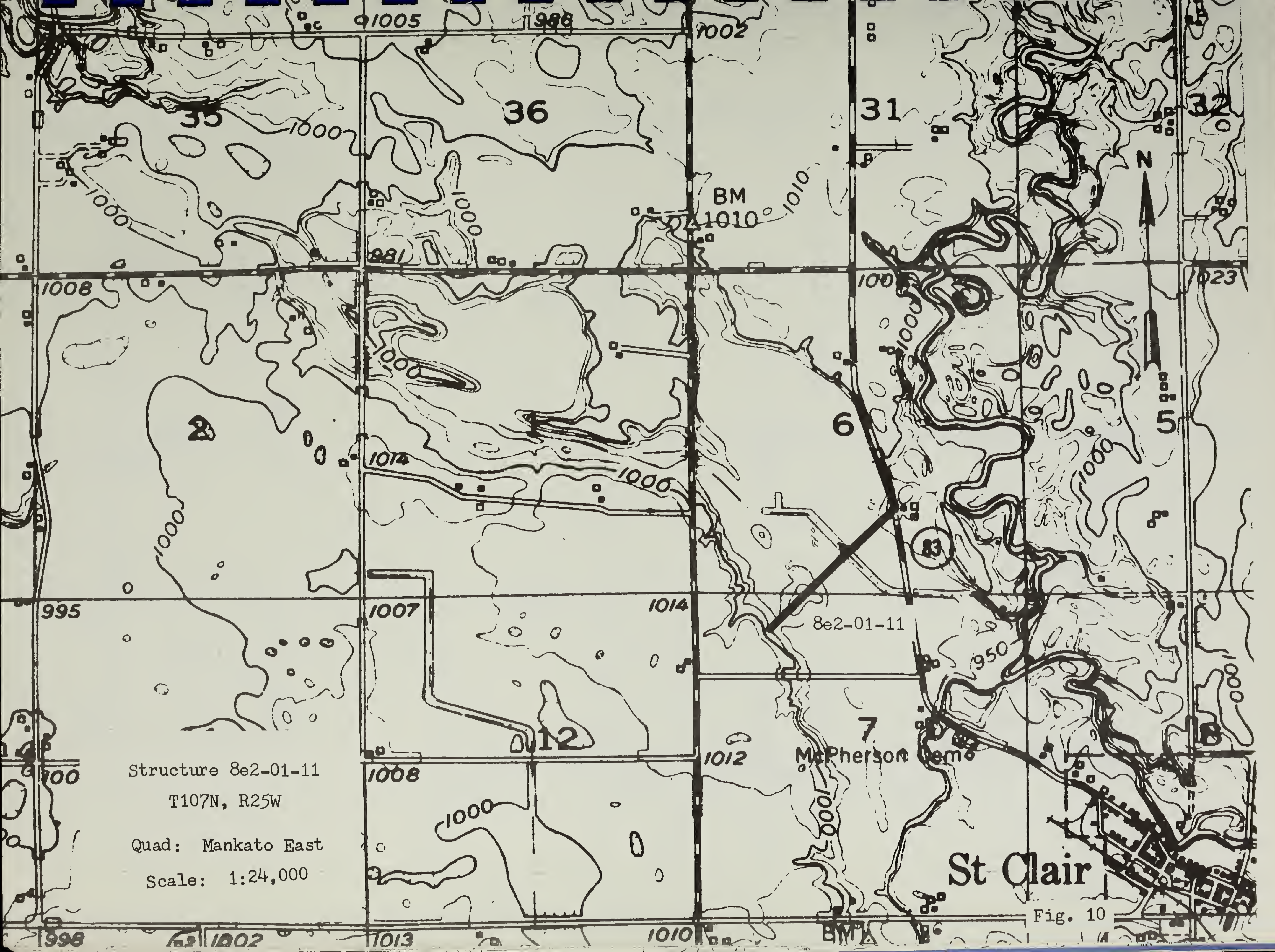
Structure 8e2-01-10
T108N, R26W

Structure 8e2-01-12
T108N, R25W

Quad: Mankato East

Scale: 1:24,000

Fig. 9



Structure 8e2-01-11
T107N, R25W

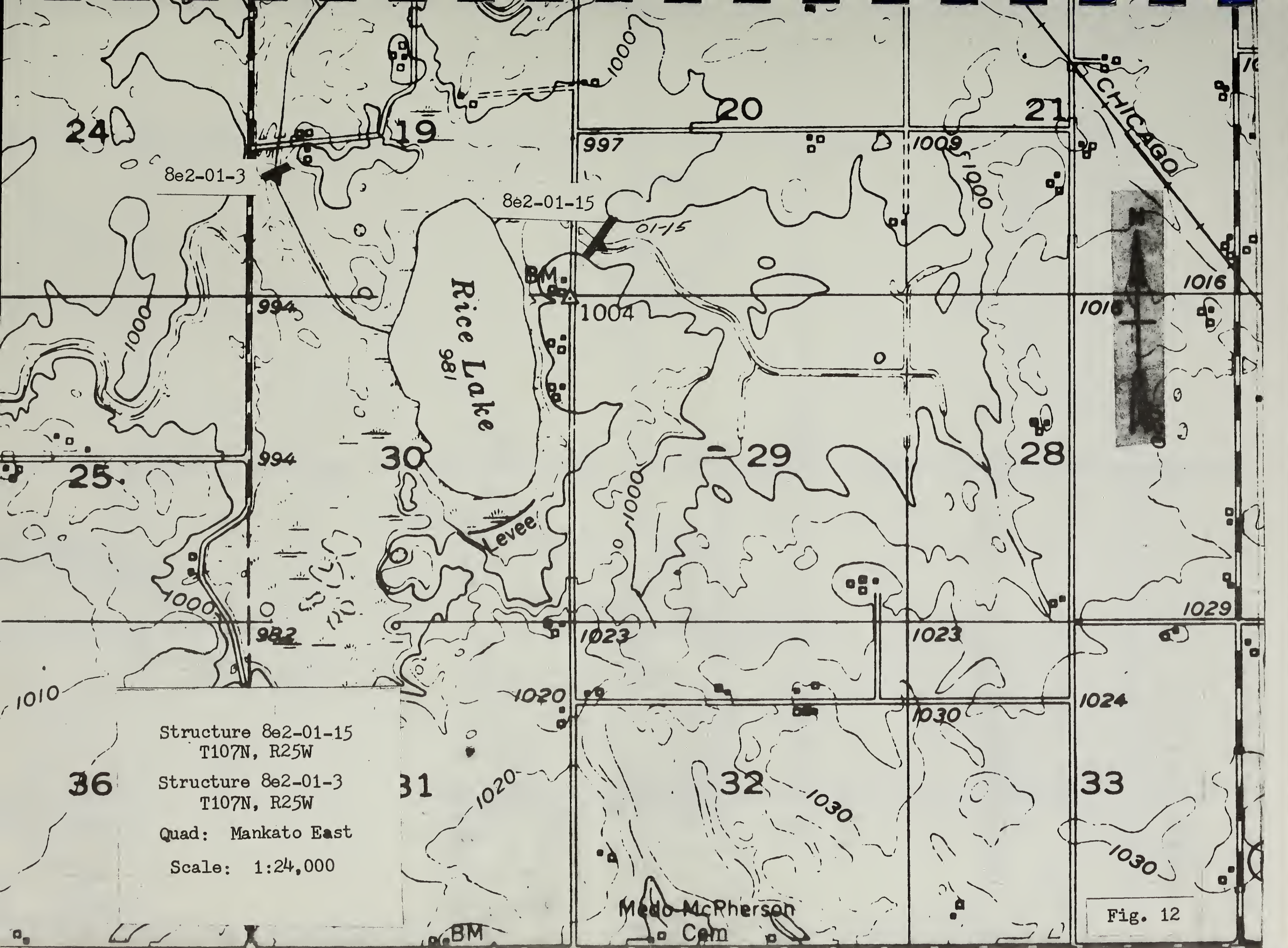
Quad: Mankato East

Scale: 1:24,000

Fig. 10


Indian Lake
1021
Sehorn Sch
8e2-01-14
N
33
34
35
4
3
2
11
10
1
1010
1000
1050
1040
1044
1036
1038
1030
1009
991
1008
990
1034
1040
1028
1019
1064
983
Structure 8e2-01-14
T107N, R25W
Quad: Mankato East
Scale: 1:24,000

Fig. 11



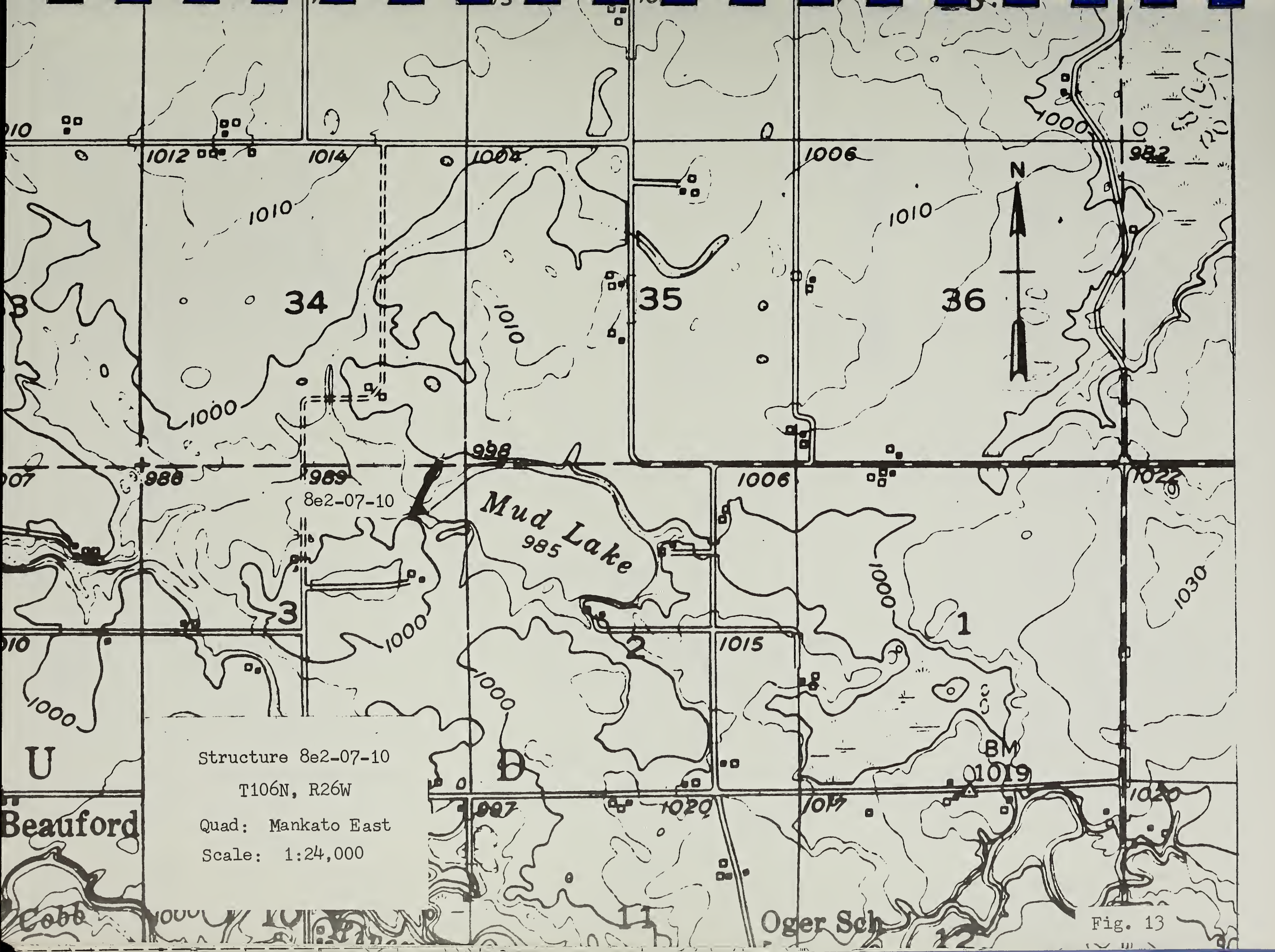
Structure 8e2-01-15
T107N, R25W

Structure 8e2-01-3
T107N, R25W

Quad: Mankato East

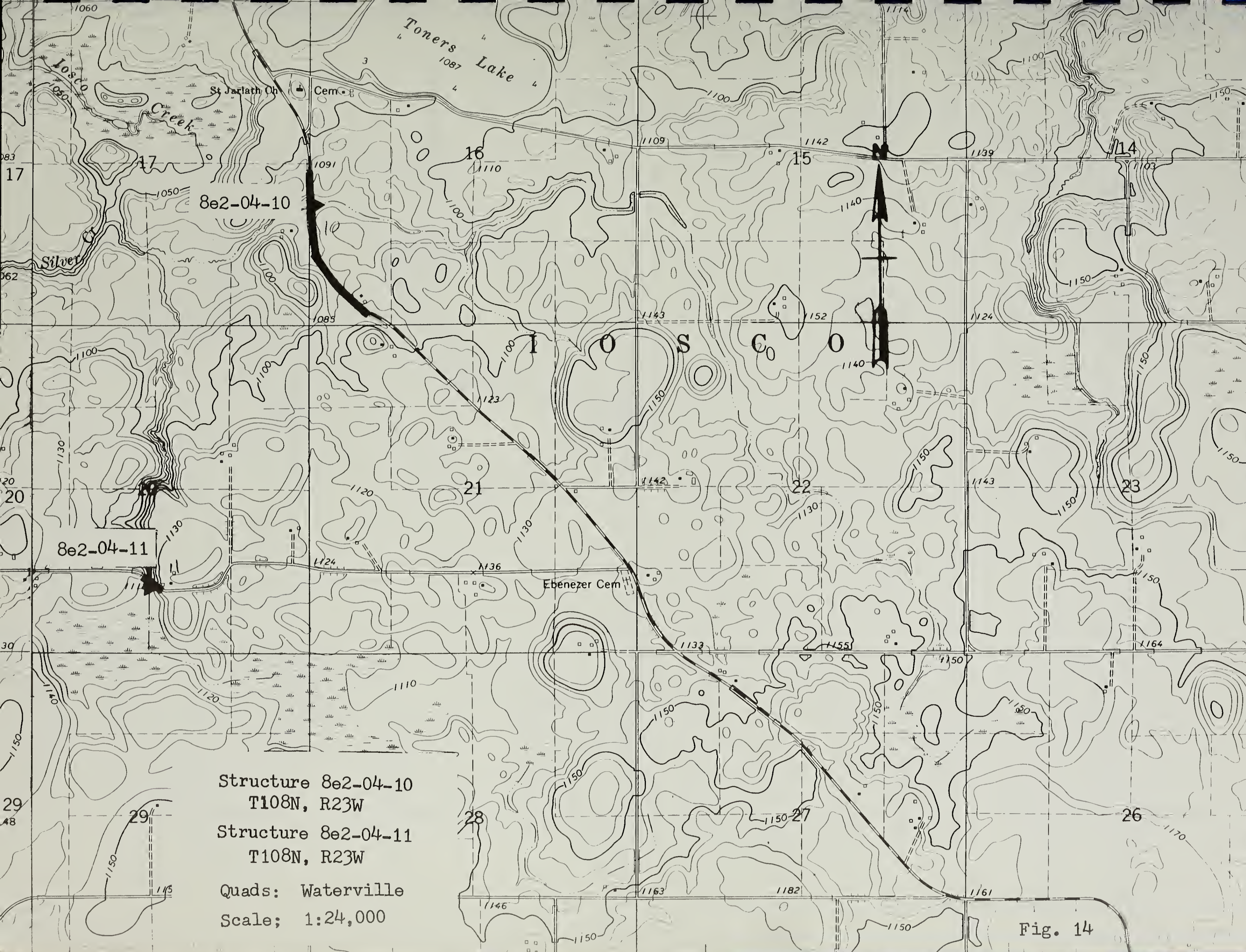
Scale: 1:24,000

Fig. 12



Structure 8e2-07-10
T106N, R26W
Quad: Mankato East
Scale: 1:24,000

Fig. 13

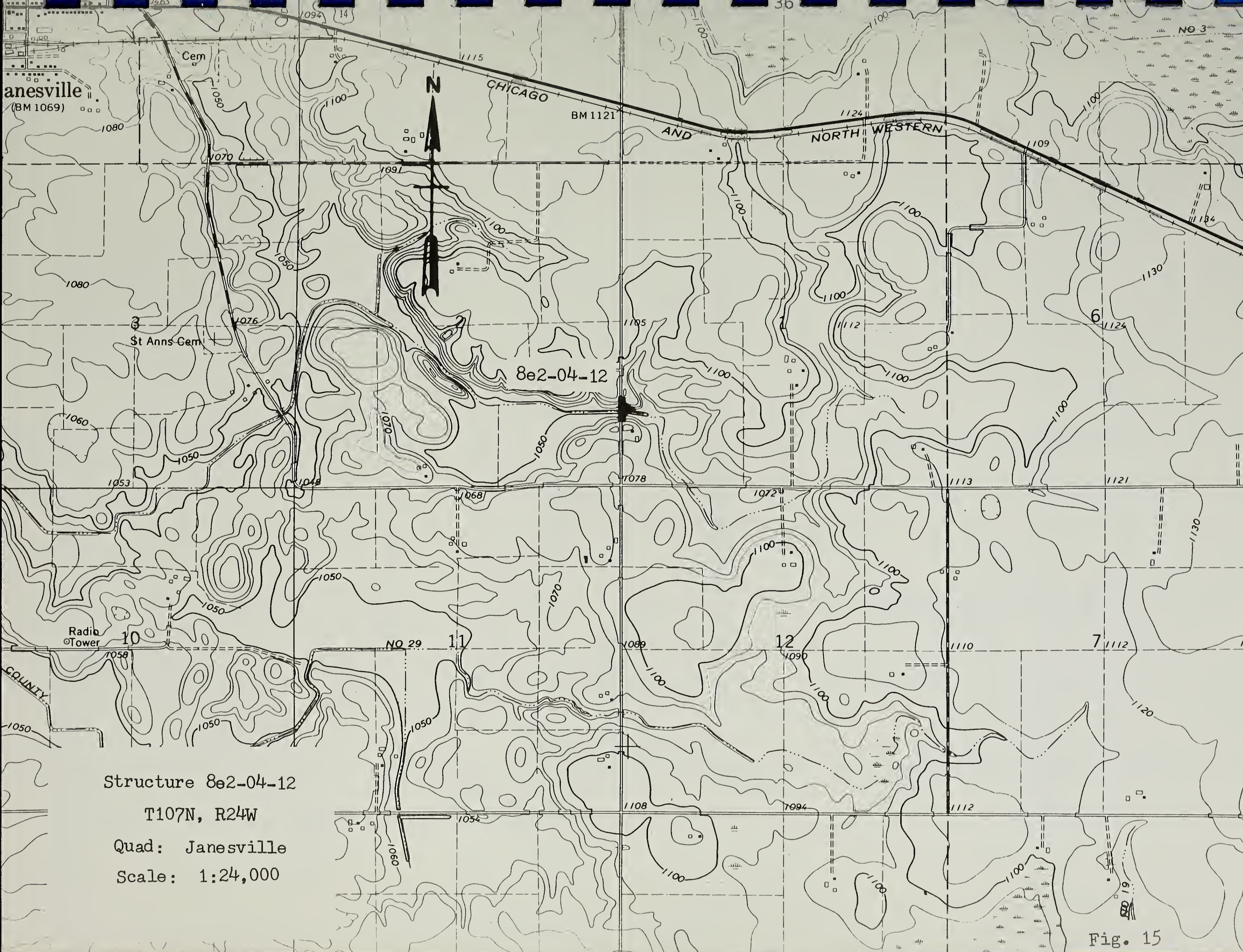


Structure 8e2-04-10
T108N, R23W
Structure 8e2-04-11
T108N, R23W

Quads: Waterville

Scale; 1:24,000

Fig. 14



Structure 8e2-04-12

T107N, R24W

Quad: Janesville

Scale: 1:24,000

Fig. 15

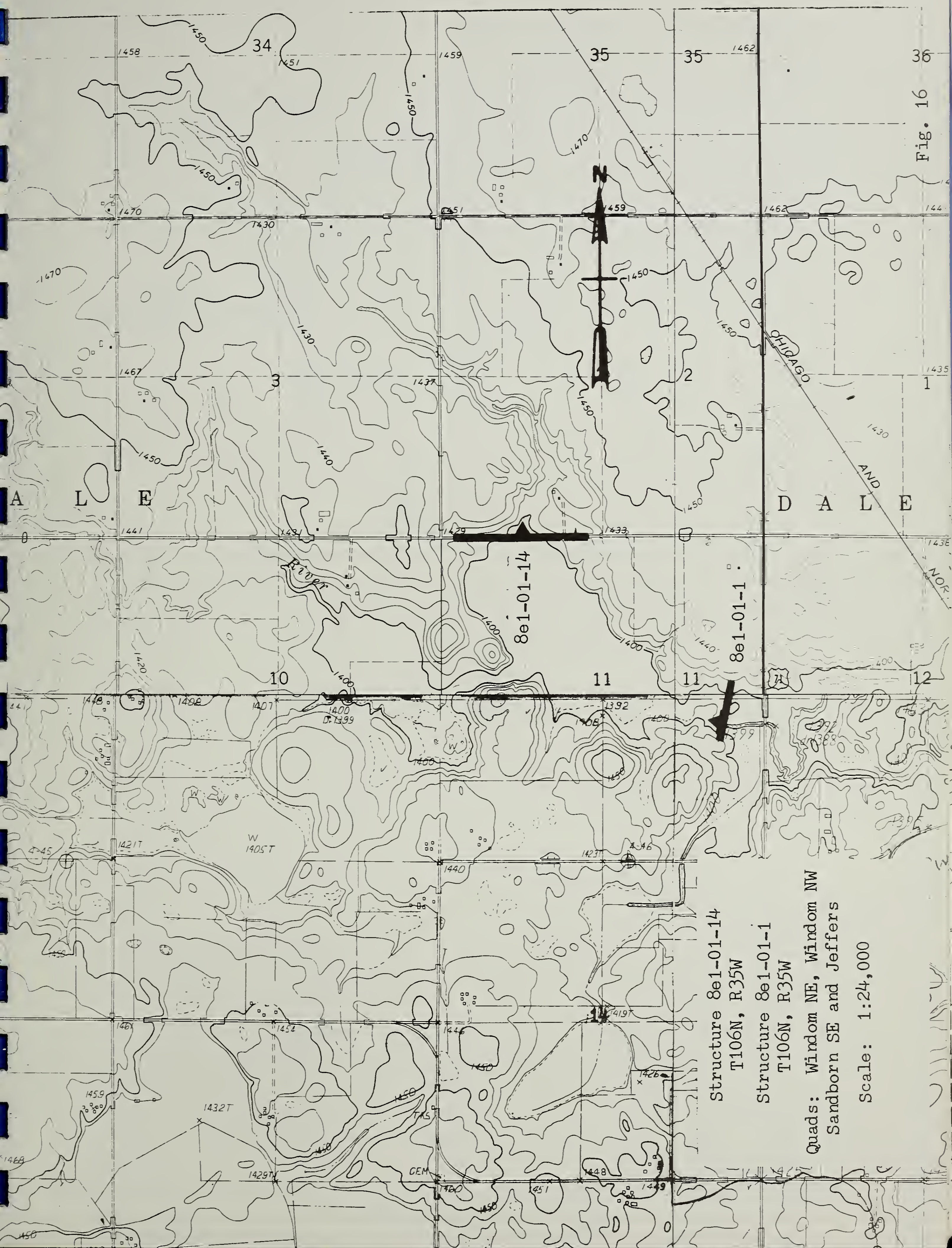


Fig. 16

Structure 8e1-01-14
T106N, R35W
Structure 8e1-01-1
T106N, R35W
Quads: Windom NE, Windom NW
Sandborn SE and Jeffers
Scale: 1:24,000

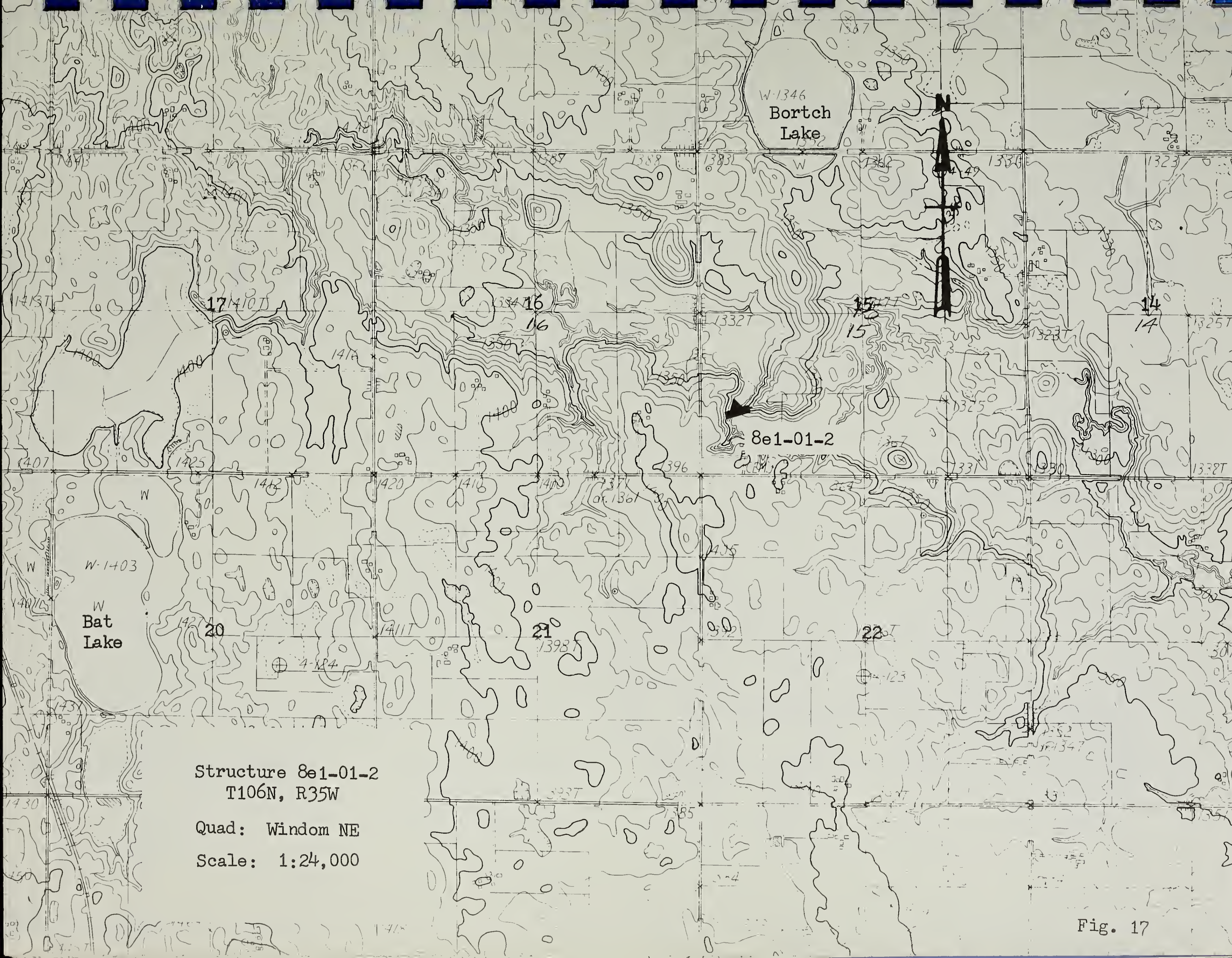

Bortch Lake
W-1346
Bat Lake
W-1403
8e1-01-2
14
15
16
17
20
21
22
Structure 8e1-01-2
T106N, R35W
Quad: Windom NE
Scale: 1:24,000

Fig. 17

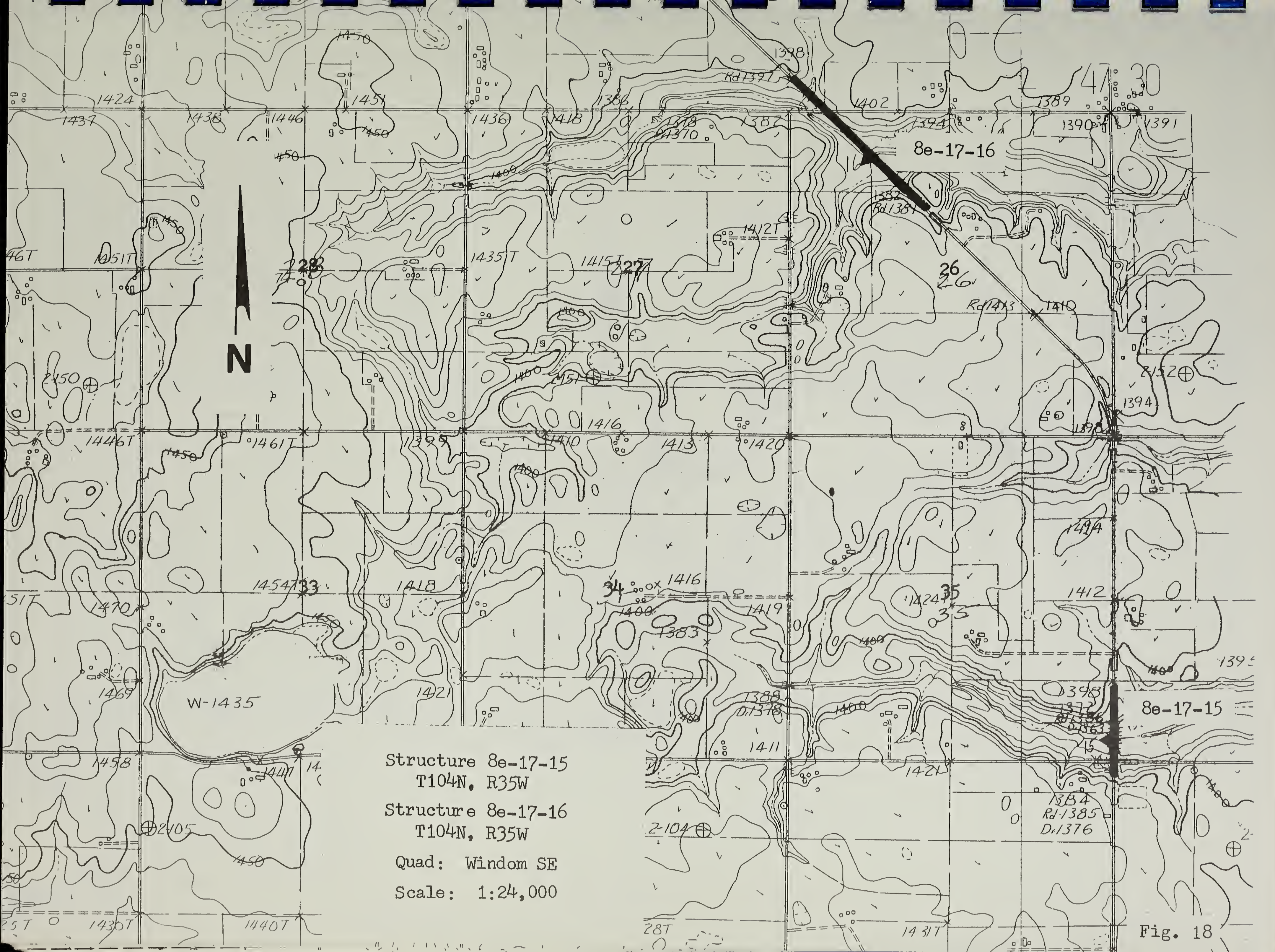
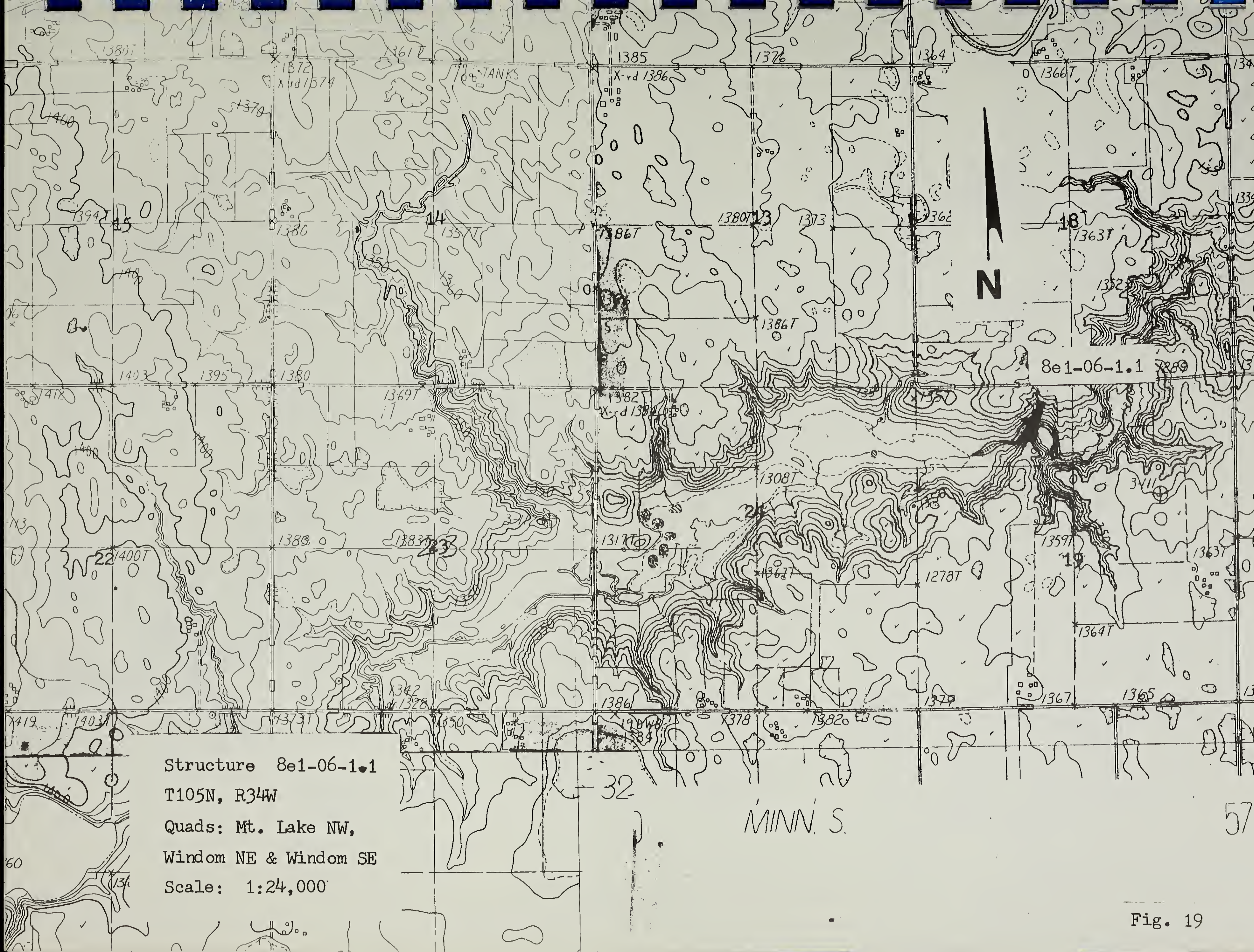

8e-17-16
8e-17-15
N
W-1435
Structure 8e-17-15
T104N, R35W
Structure 8e-17-16
T104N, R35W
Quad: Windom SE
Scale: 1:24,000

Fig. 18



Structure 8e1-06-1.1
T105N, R34W
Quads: Mt. Lake NW,
Windom NE & Windom SE
Scale: 1:24,000

Fig. 19

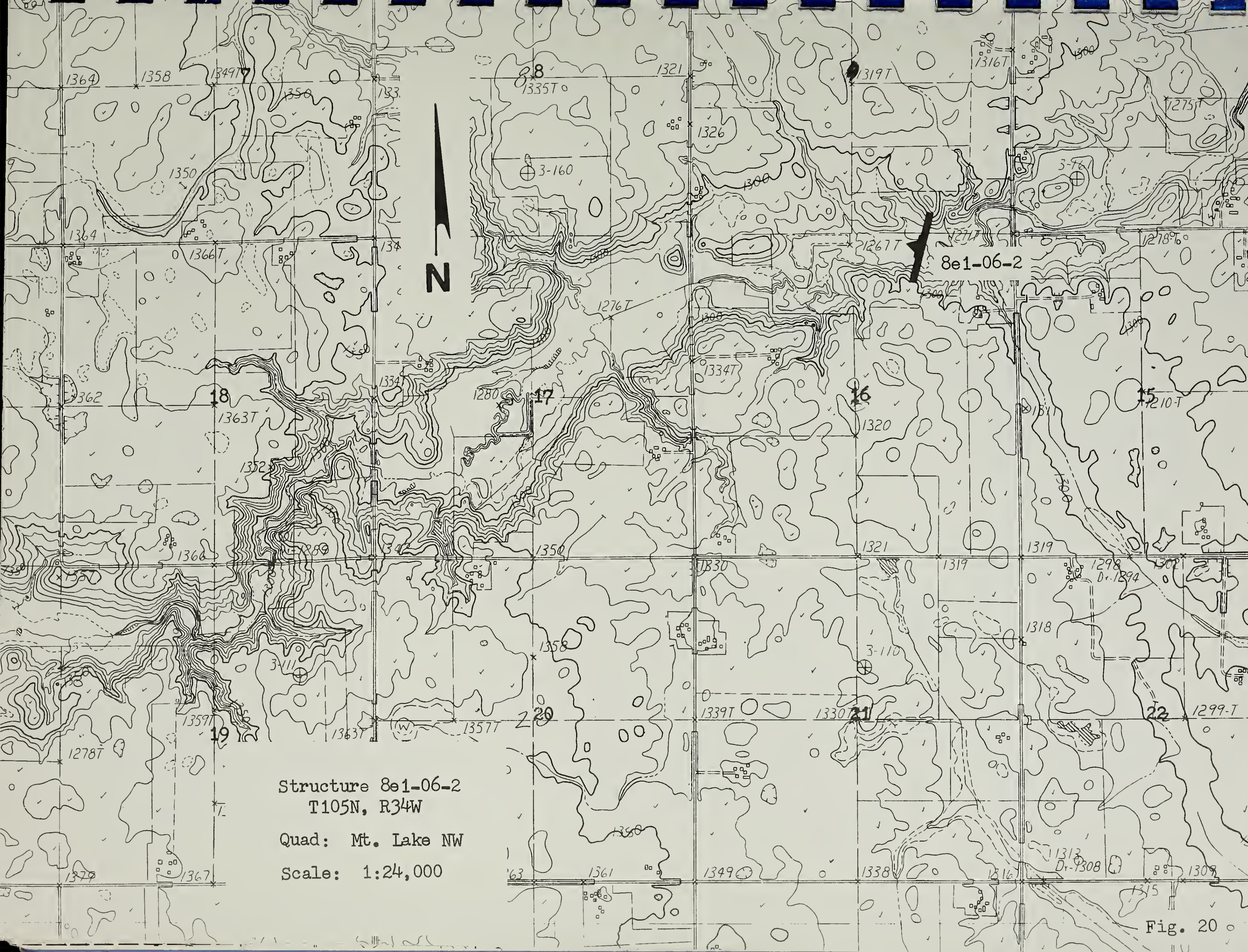
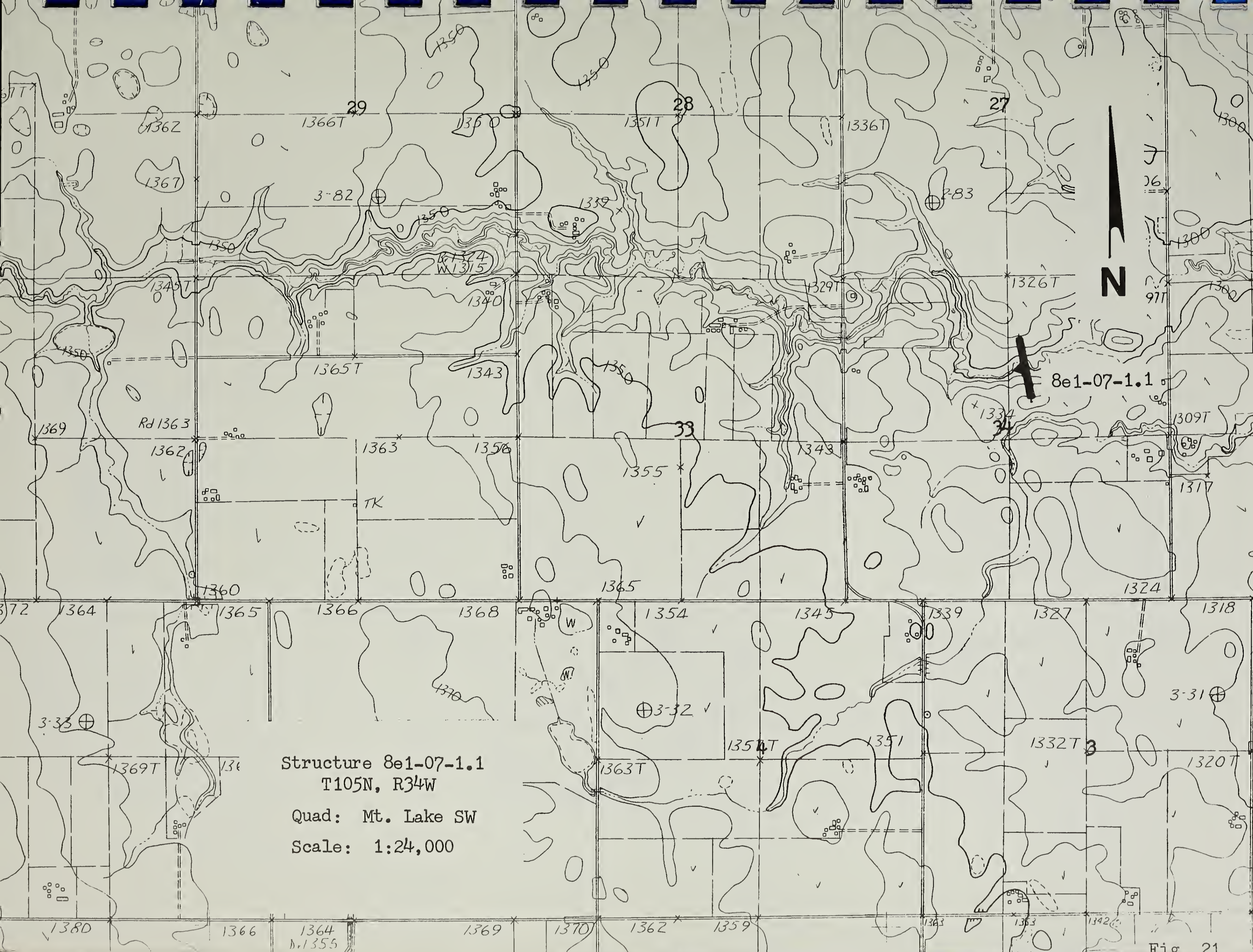

8e1-06-2
N
Structure 8e1-06-2
T105N, R34W
Quad: Mt. Lake NW
Scale: 1:24,000

Fig. 20



Structure 8e1-07-1.1
T105N, R34W

Quad: Mt. Lake SW

Scale: 1:24,000

Fig. 21

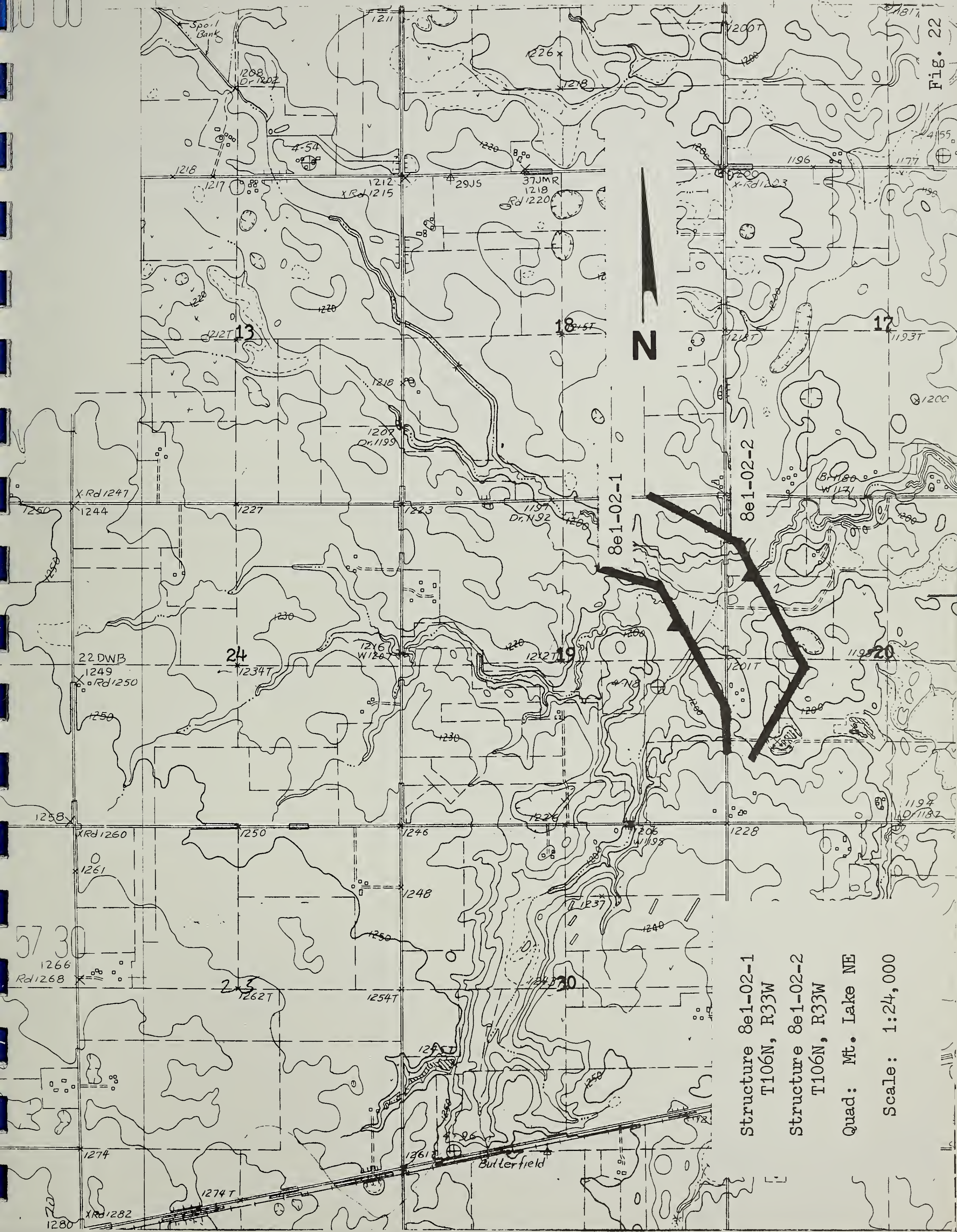


Fig. 22

Structure 8e1-02-1
T106N, R33W
Structure 8e1-02-2
T106N, R33W
Quad: Mt. Lake NE

Scale: 1:24,000

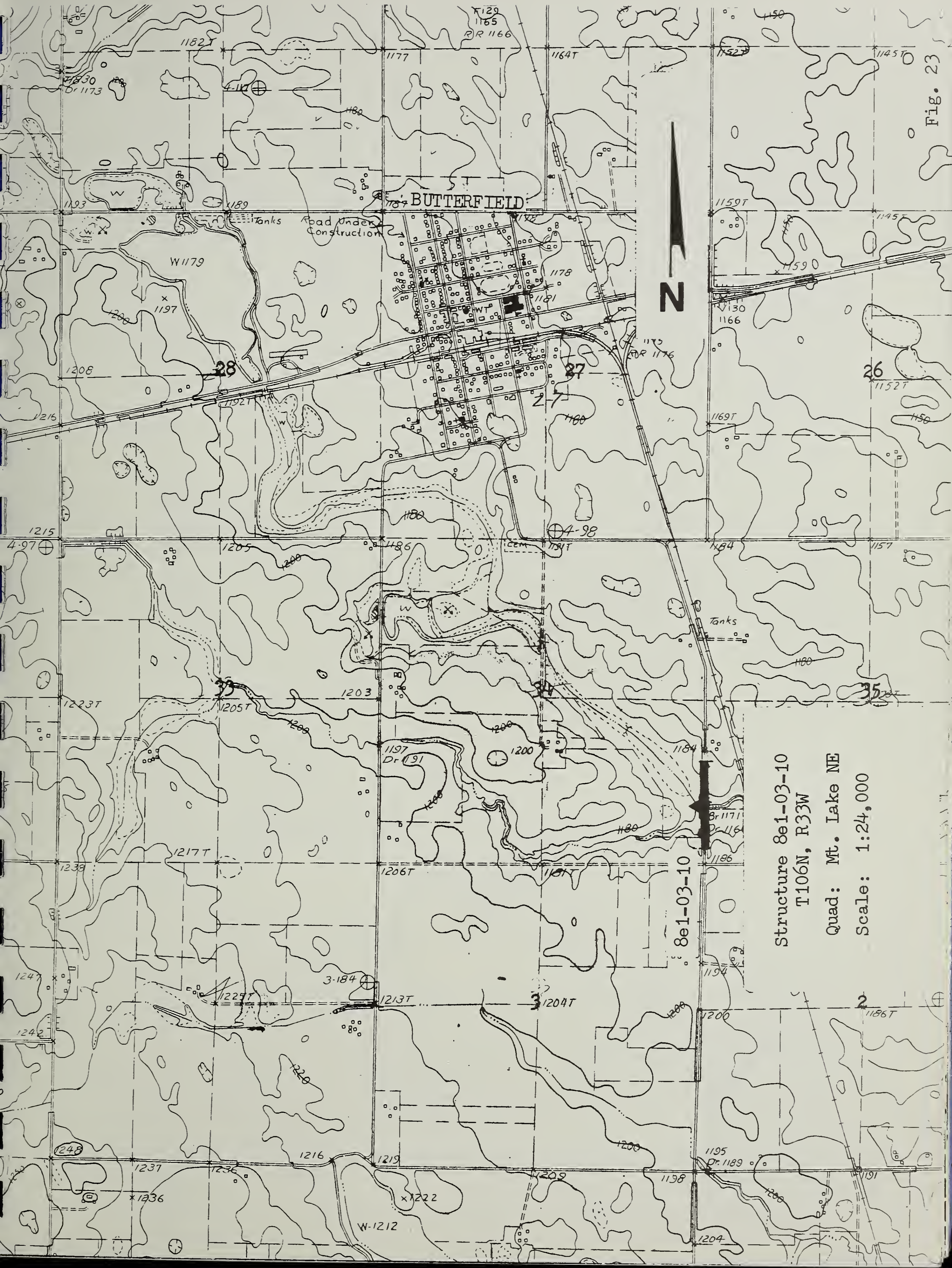


Fig. 23

Structure 8e1-03-10
T106N, R33W
Quad: Mt. Lake NE
Scale: 1:24,000

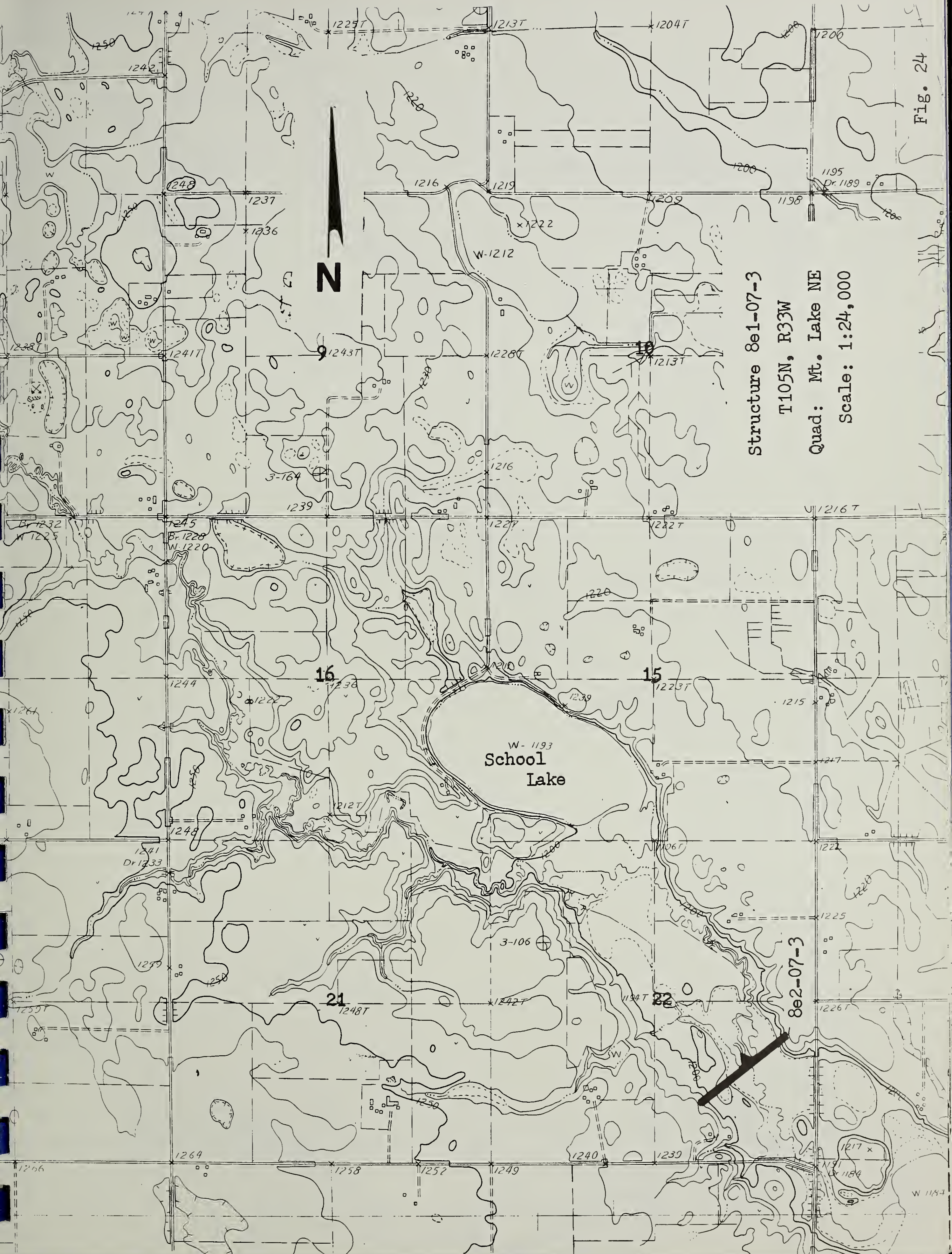


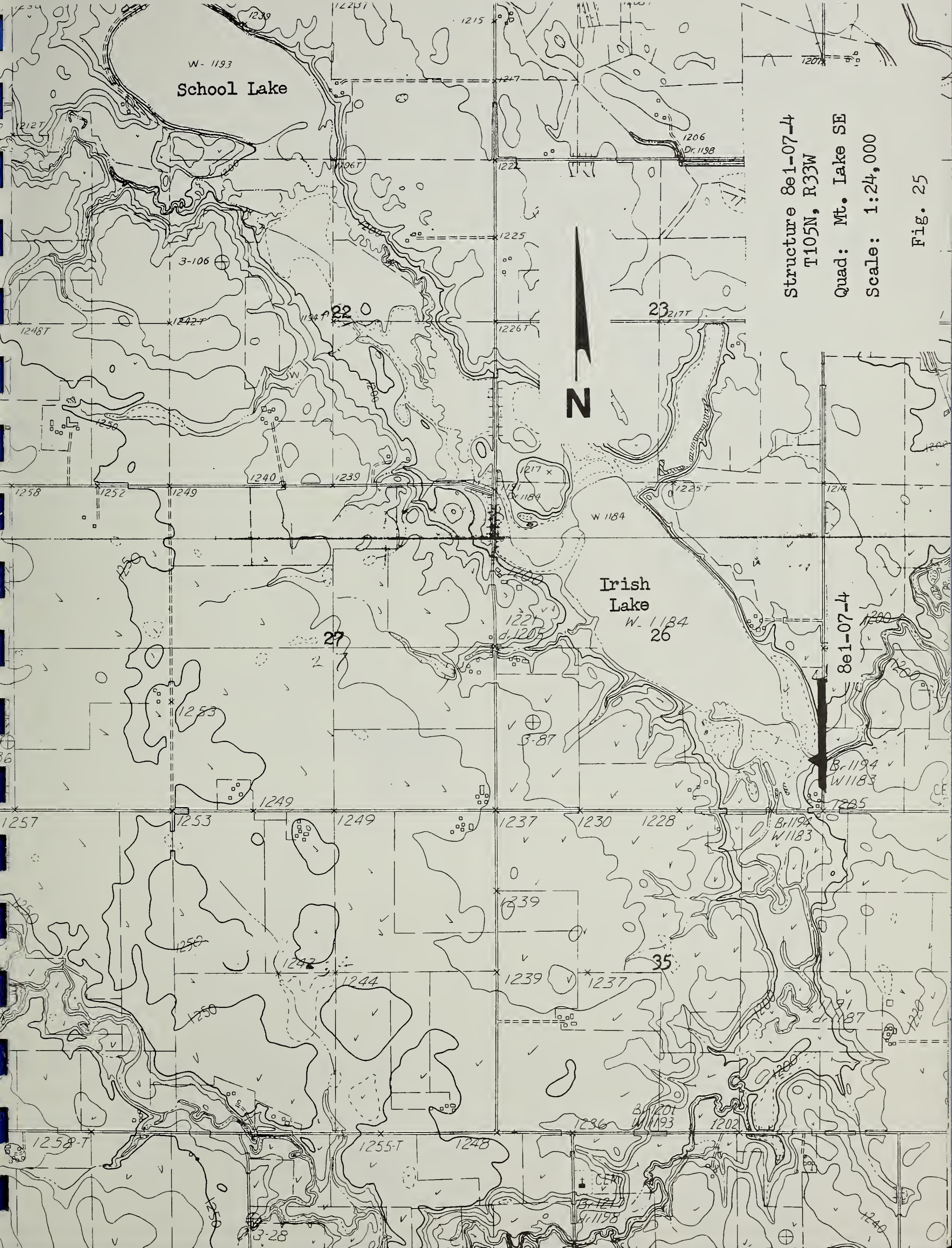
Fig. 24

Structure 8e1-07-3

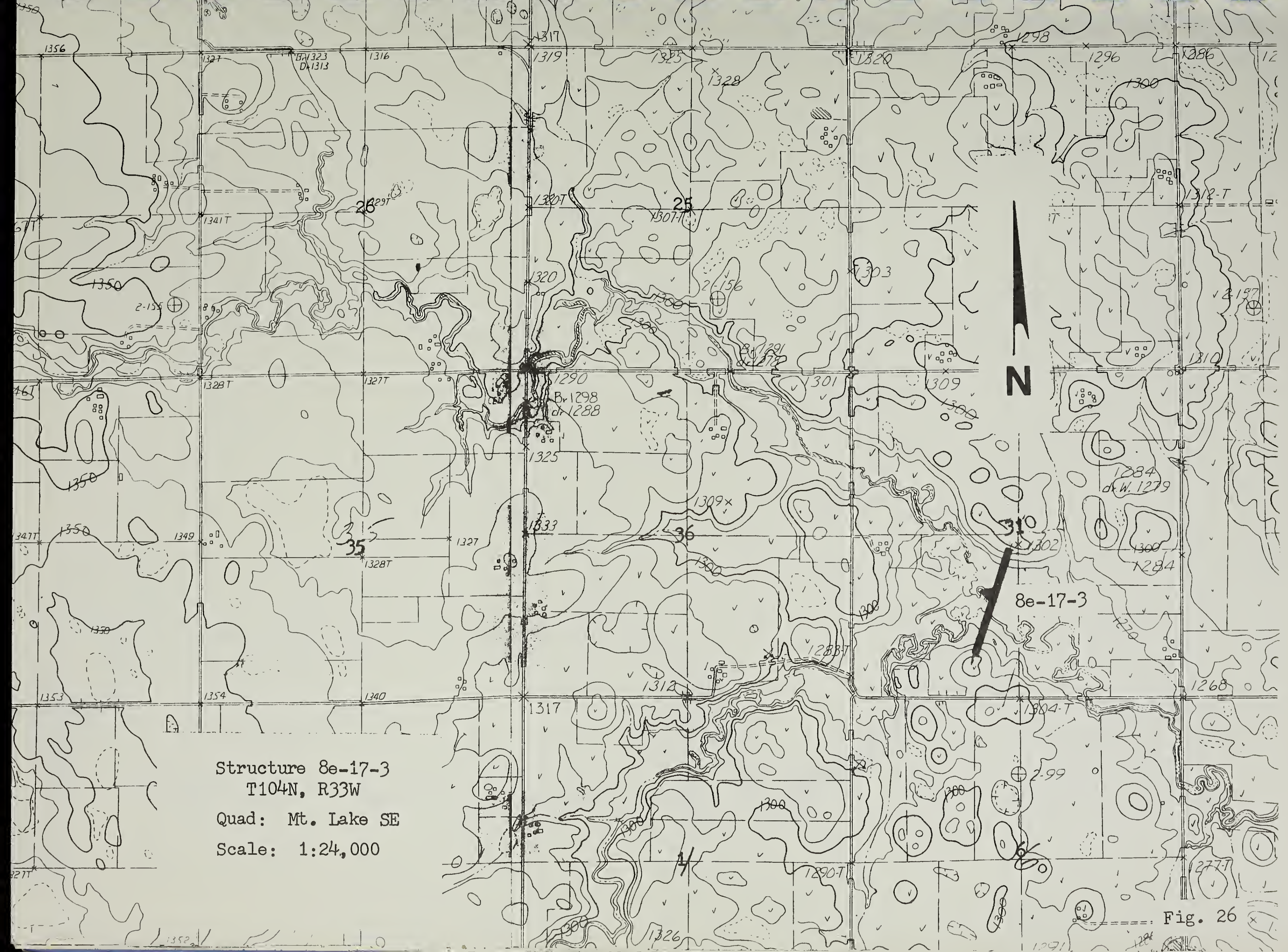
T105N, R33W

Quad: Mt. Lake NE

Scale: 1:24,000



Structure 8e1-07-4
T105N, R33W
Quad: Mt. Lake SE
Scale: 1:24,000
Fig. 25

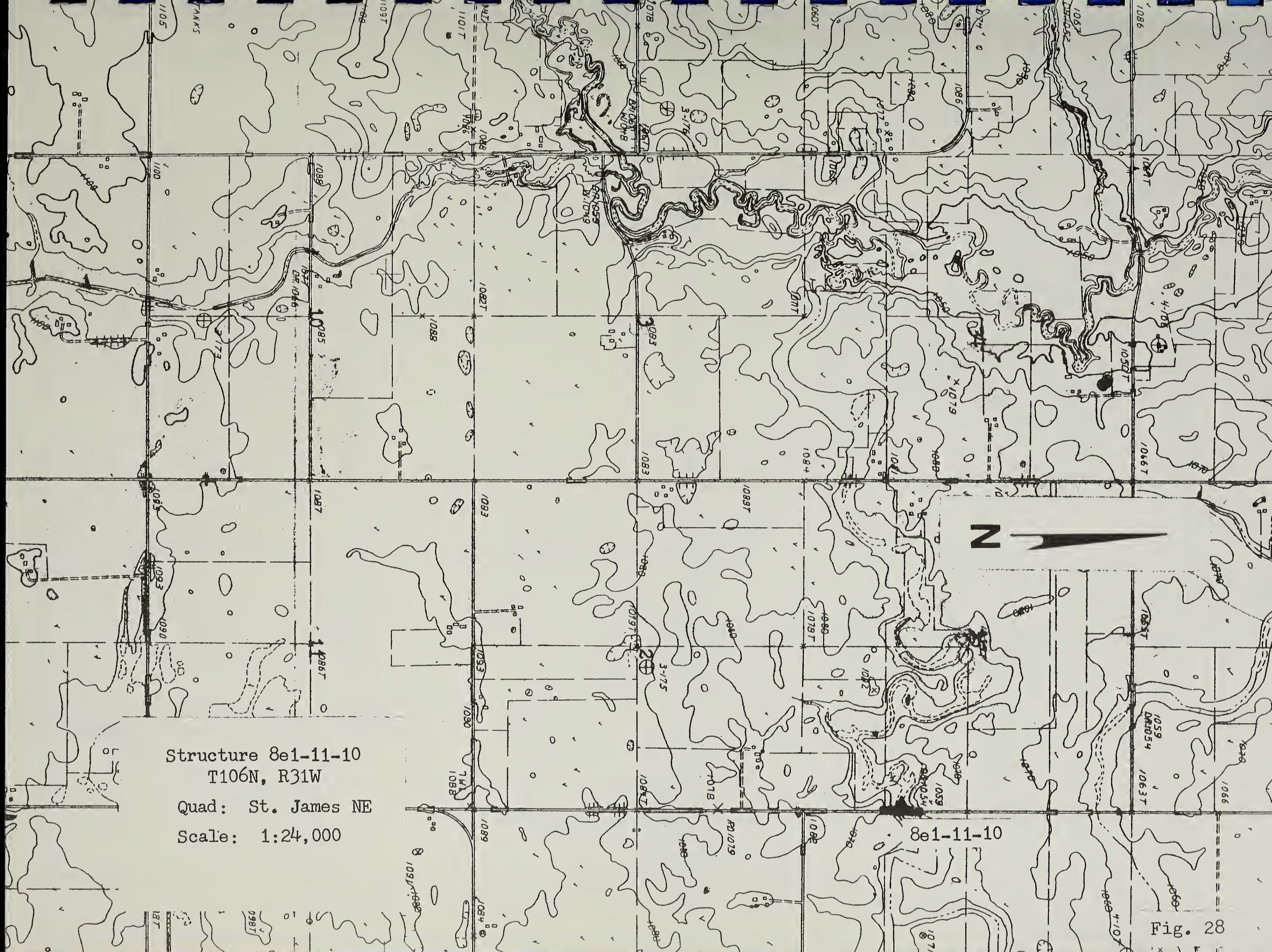


Structure 8e-17-3
T104N, R33W
Quad: Mt. Lake SE
Scale: 1:24,000

Fig. 26

Fig. 27

Structure 8e1-03-1
T105N, R32W
Quad: St. James NW
Scale: 1:24,000



Structure 8e1-11-10
T106N, R31W

Quad: St. James NE

Scale: 1:24,000

Fig. 28

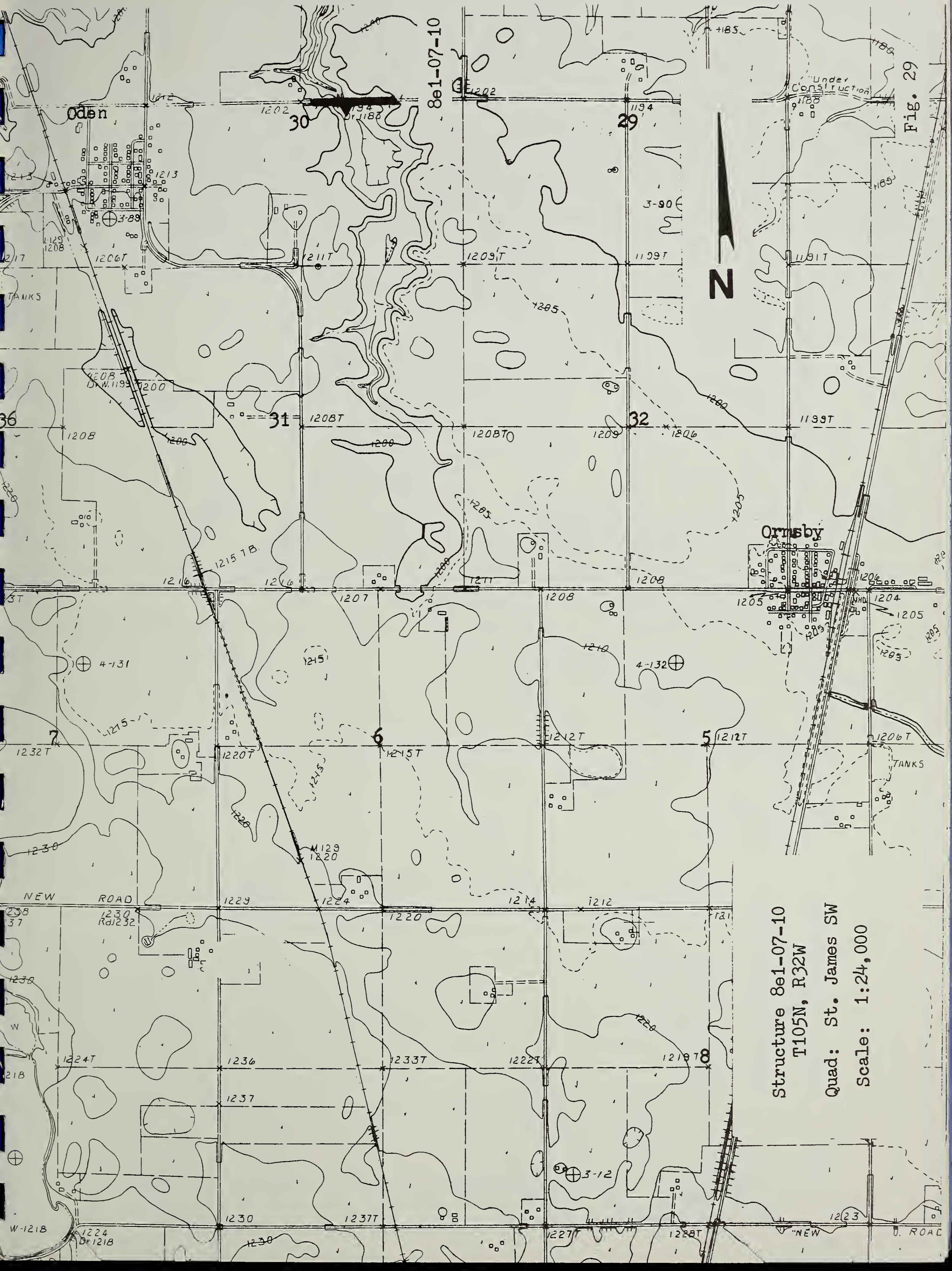


Fig. 29

Structure 8e1-07-10
T105N, R32W

Quad: St. James SW

Scale: 1:24,000

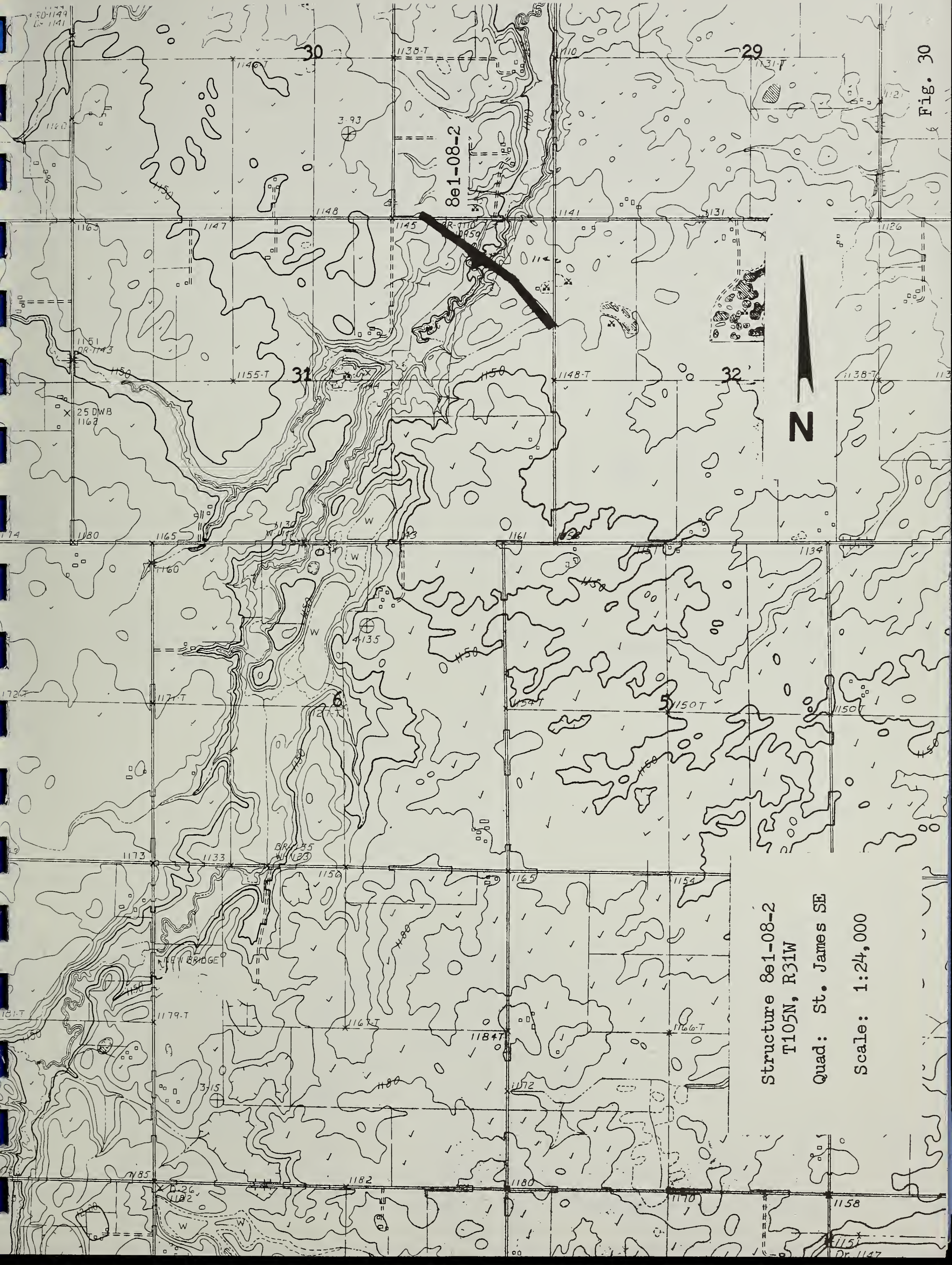


Fig. 30

Structure 8e1-08-2
T105N, R31W
Quad: St. James SE

Scale: 1:24,000

Fig. 31

Structure 8e-17-17
T104N, R31W
Quad: St. James SE
Scale: 1:24,000

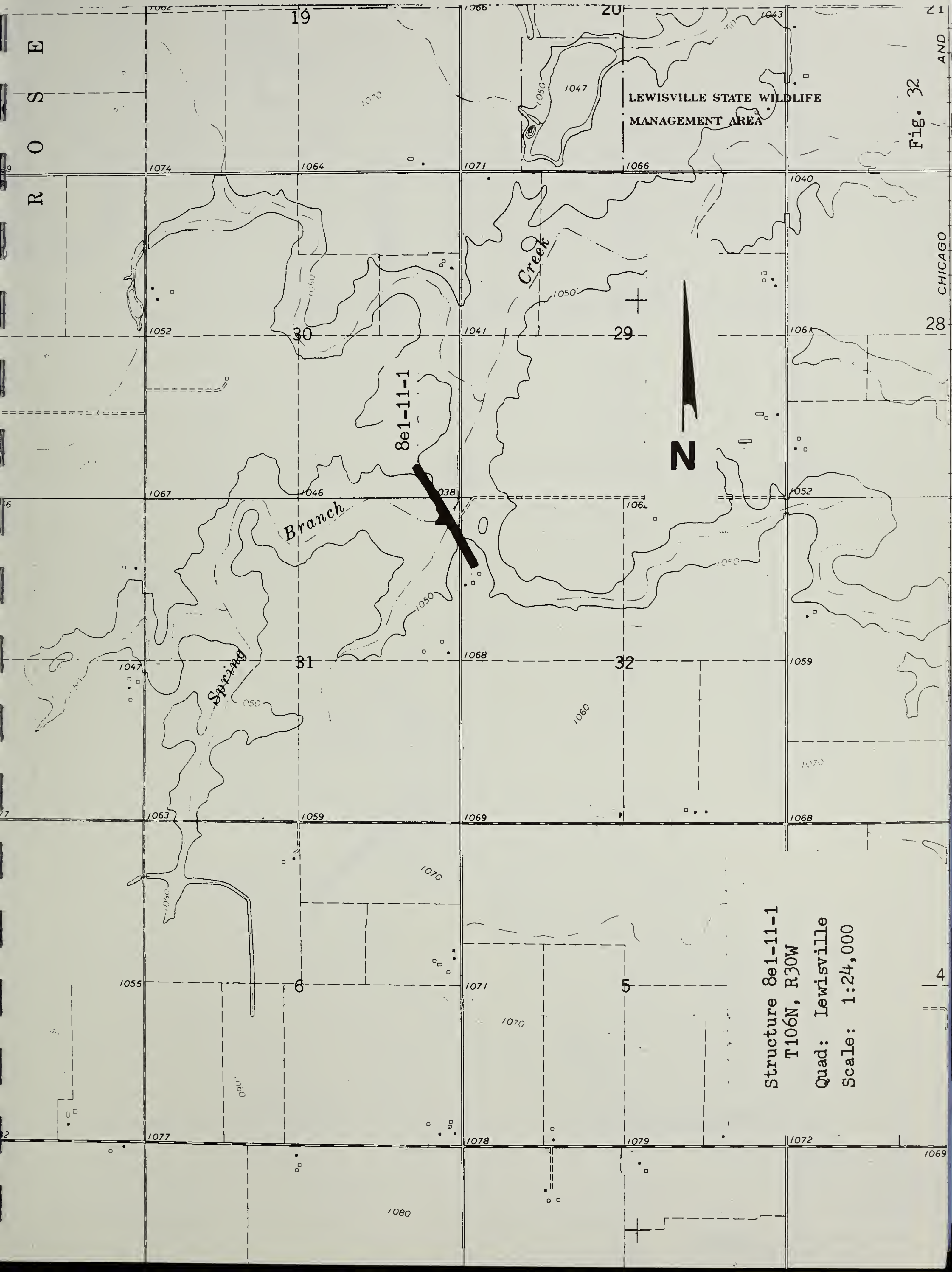


Fig. 32

Structure 8e1-11-1
T106N, R30W
Quad: Lewisville
Scale: 1:24,000

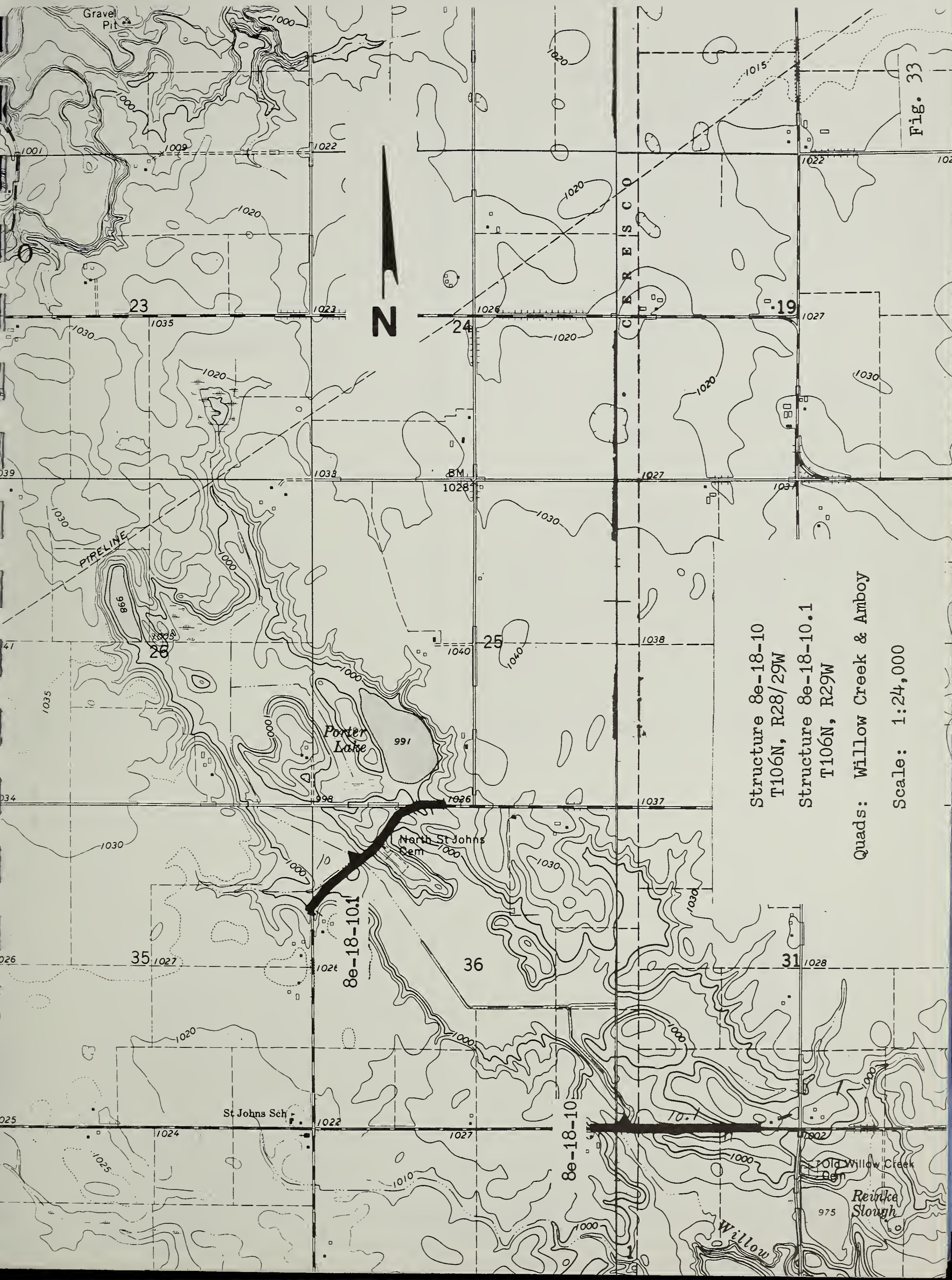


Fig. 33

Structure 8e-18-10
T106N, R28/29W
Structure 8e-18-10.1
T106N, R29W

Quads: Willow Creek & Amboy

Scale: 1:24,000

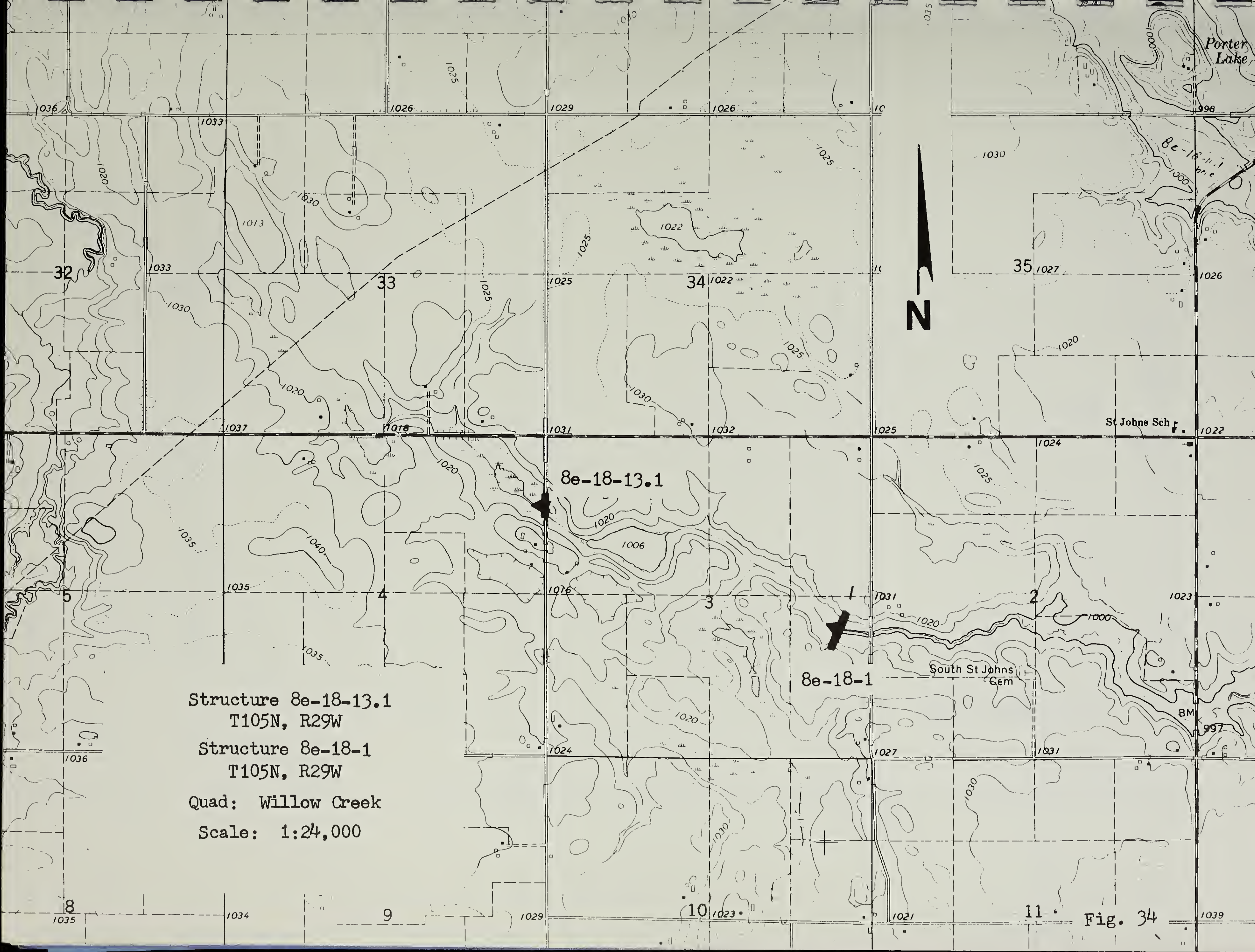

Porter Lake
8e-18-11.1
St Johns Sch
South St Johns Cem
8e-18-13.1
8e-18-1
N
32
33
34
35
2
3
4
5
8
9
10
11
Structure 8e-18-13.1
T105N, R29W
Structure 8e-18-1
T105N, R29W
Quad: Willow Creek
Scale: 1:24,000

Fig. 34

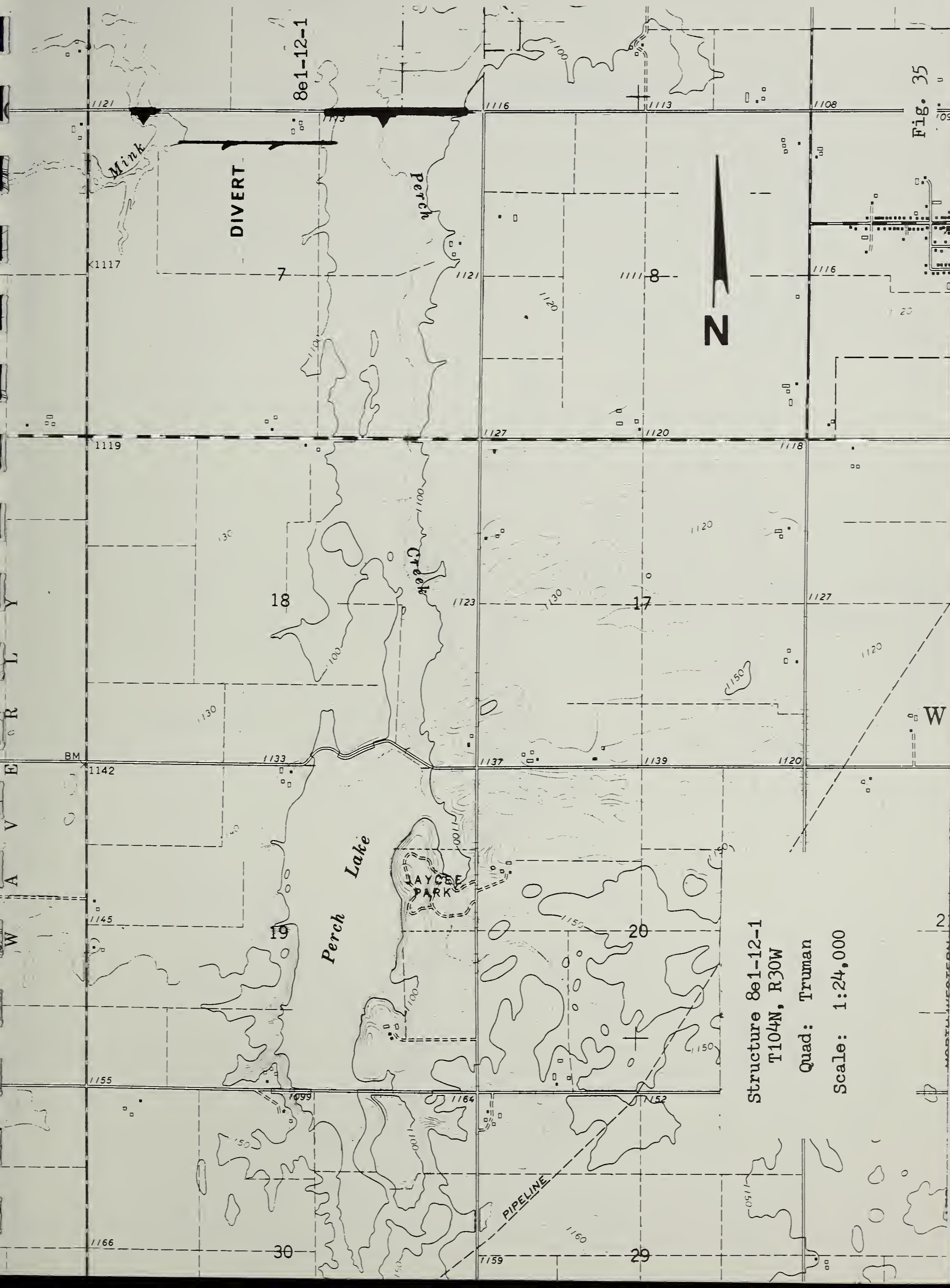


Fig. 35

Structure 8e1-12-1
T104N, R30W
Quad: Truman
Scale: 1:24,000

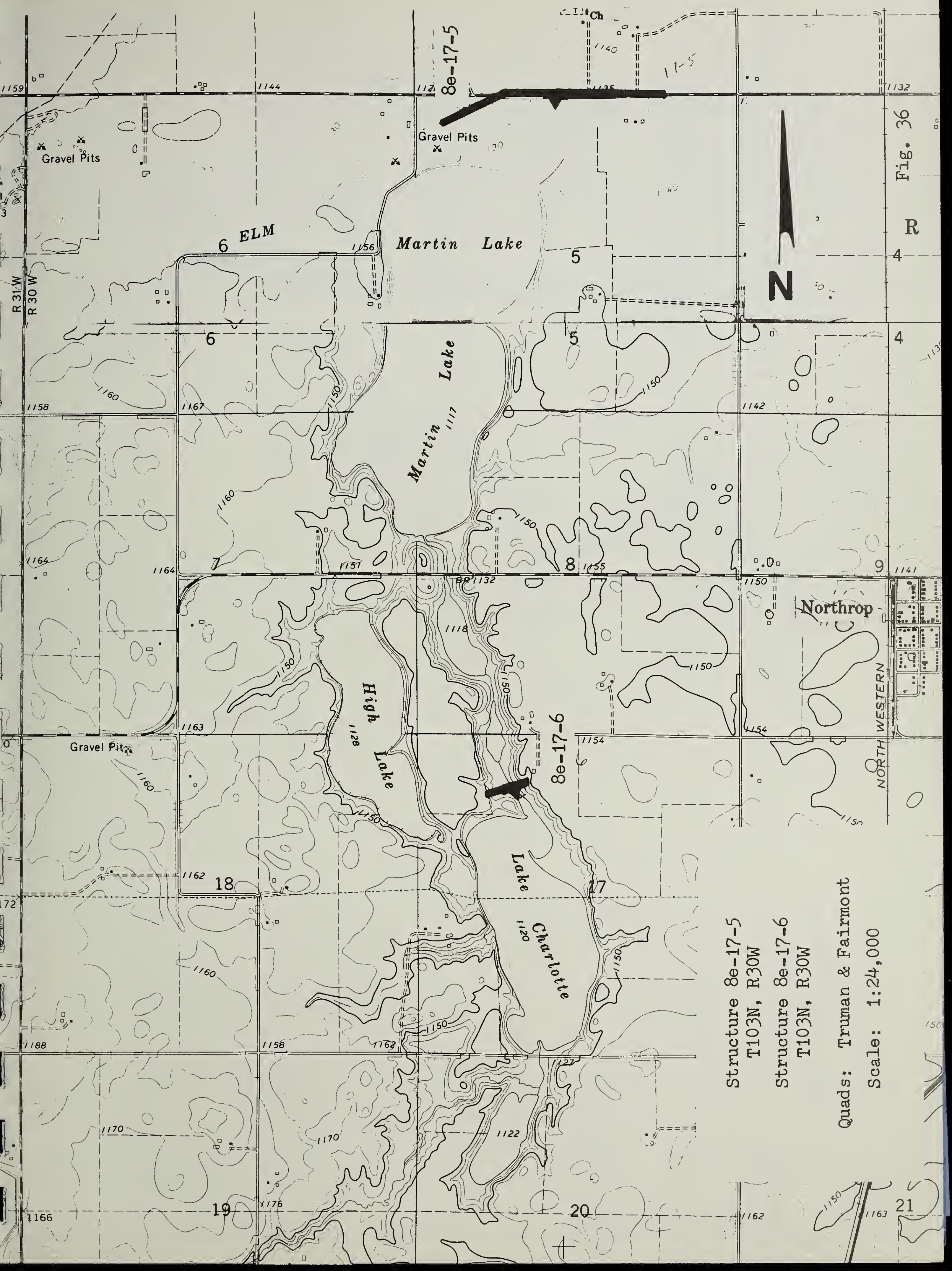
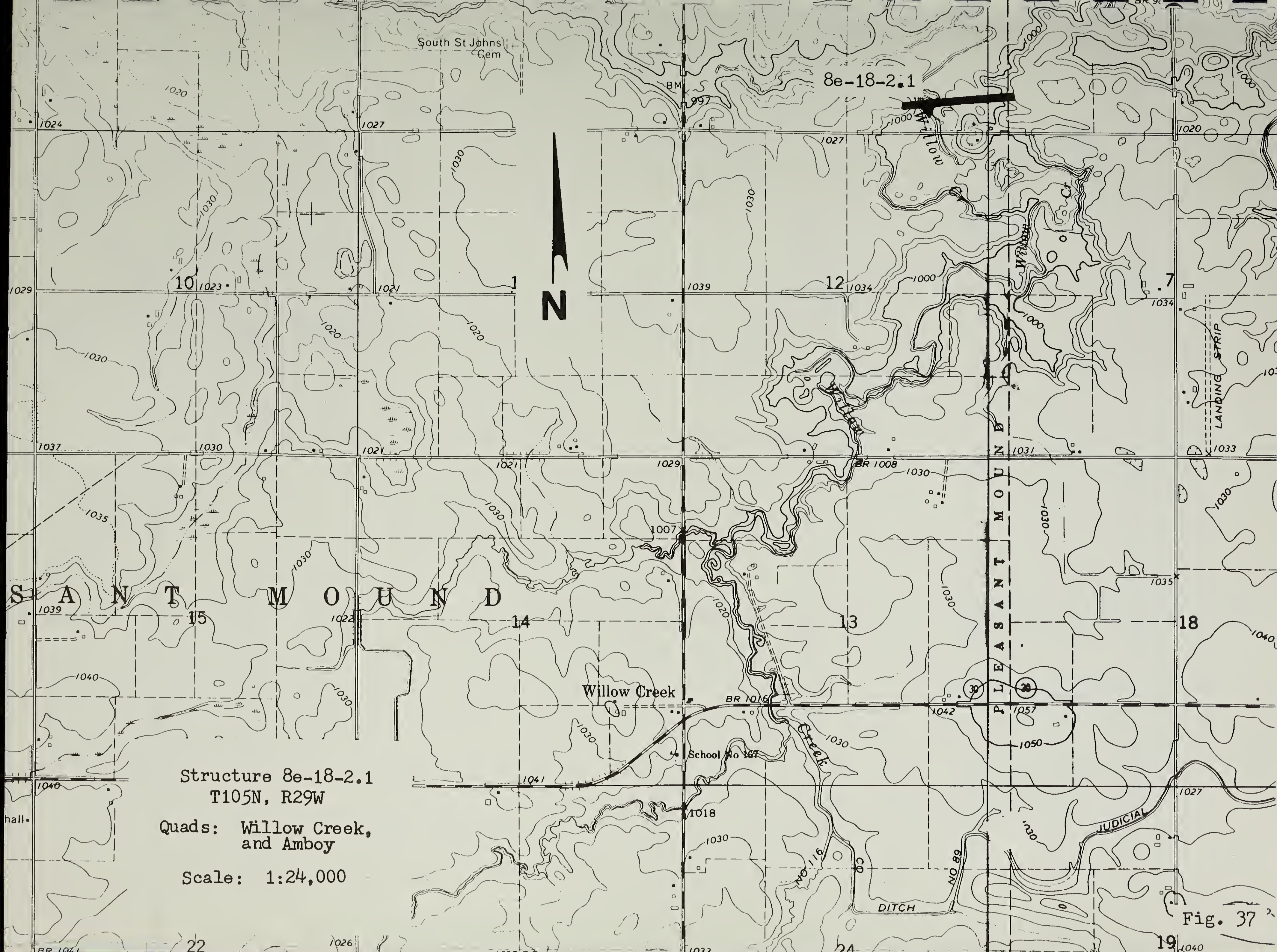


Fig. 36

Structure 8e-17-5
T103N, R30W
Structure 8e-17-6
T103N, R30W

Quads: Truman & Fairmont
Scale: 1:24,000


South St Johns Cem
8e-18-2.1
Willow Cr.
Willow Creek
School No 167
PLEASANT MOUND
LANDING STRIP
JUDICIAL
DITCH
N
Structure 8e-18-2.1
T105N, R29W
Quads: Willow Creek, and Amboy
Scale: 1:24,000
Fig. 37

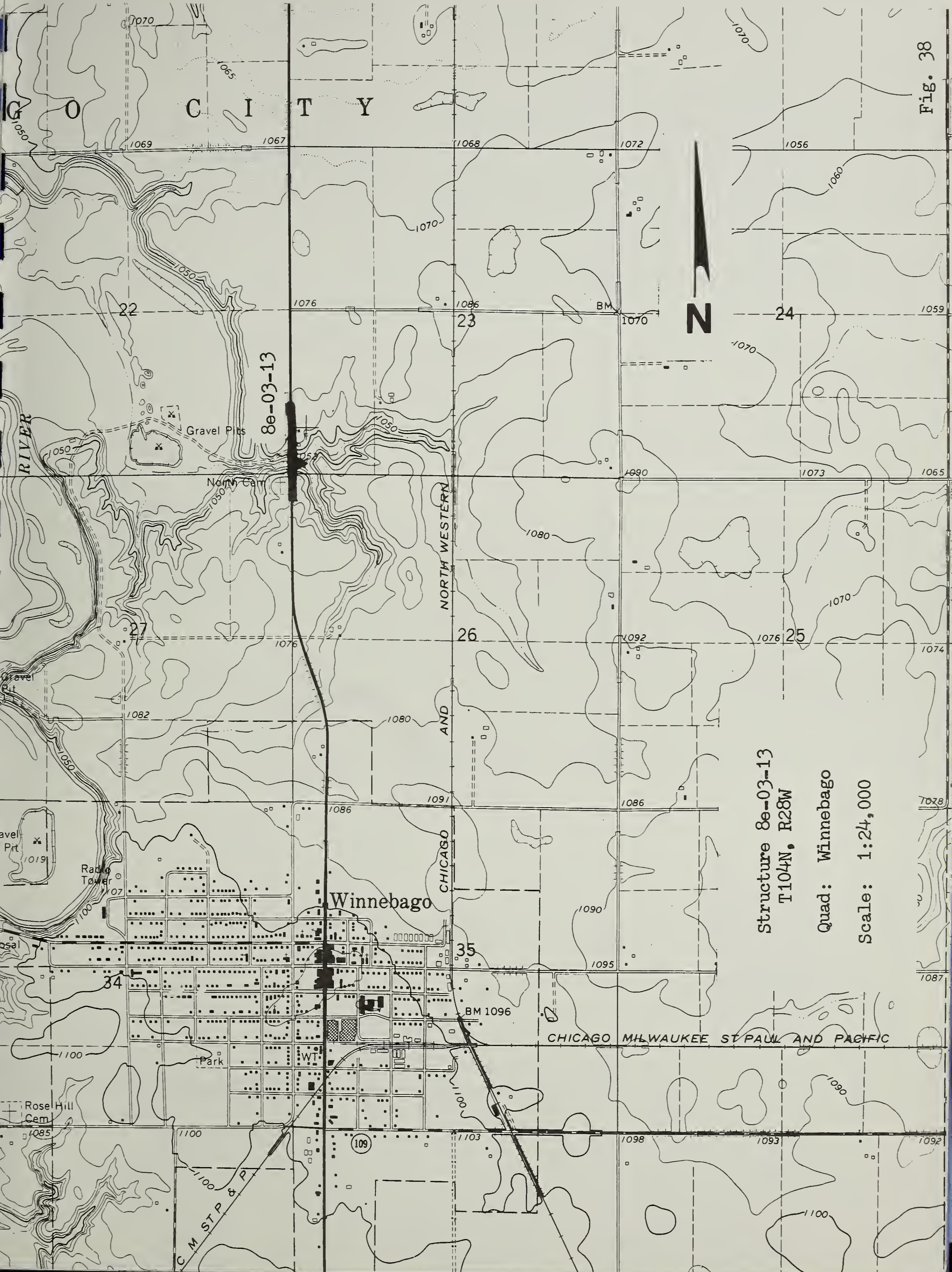
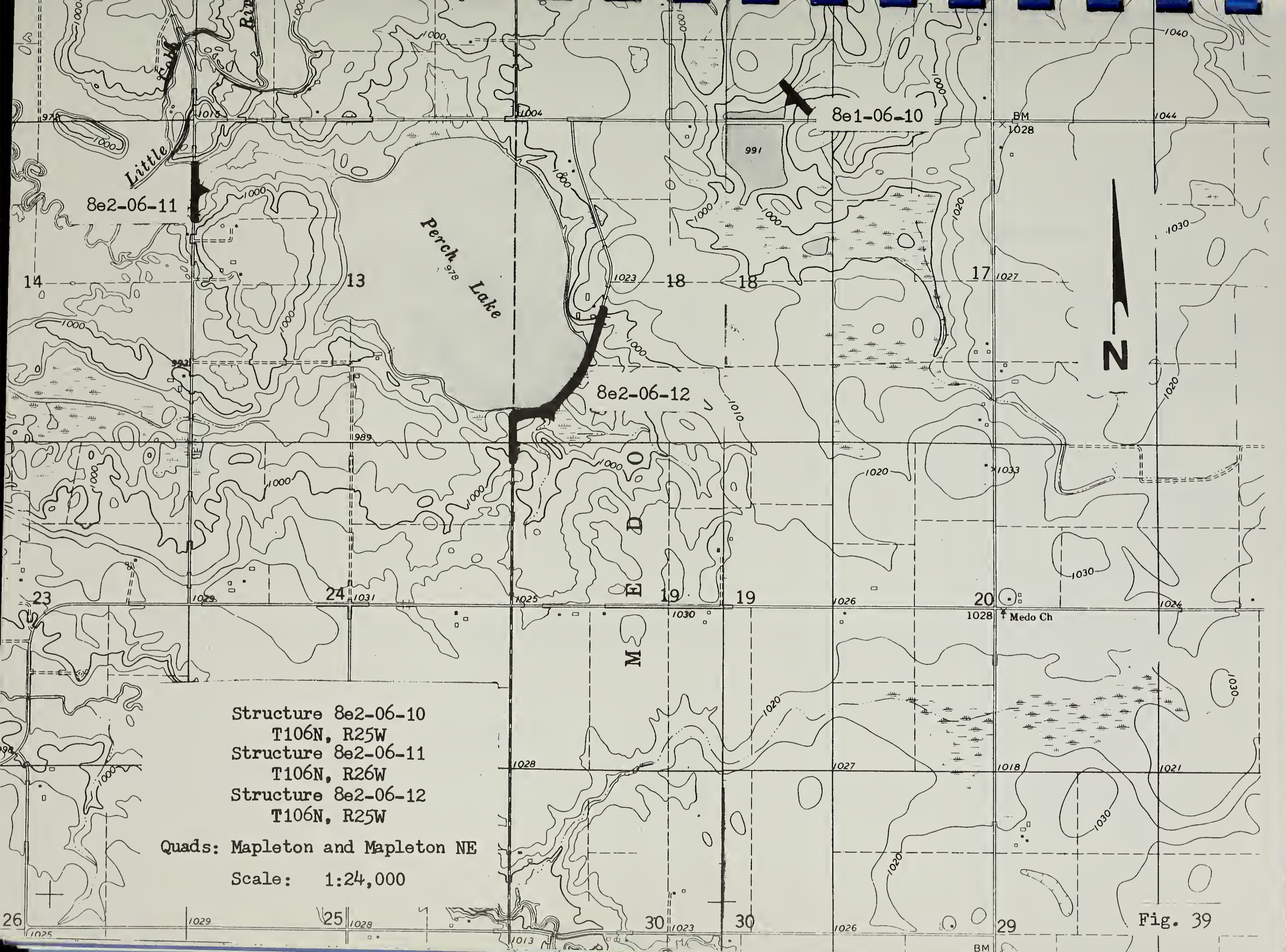


Fig. 38

Structure 8e-03-13
T104N, R28W

Quad: Winnebago

Scale: 1:24,000



Structure 8e2-06-10
T106N, R25W
Structure 8e2-06-11
T106N, R26W
Structure 8e2-06-12
T106N, R25W

Quads: Mapleton and Mapleton NE

Scale: 1:24,000

Fig. 39

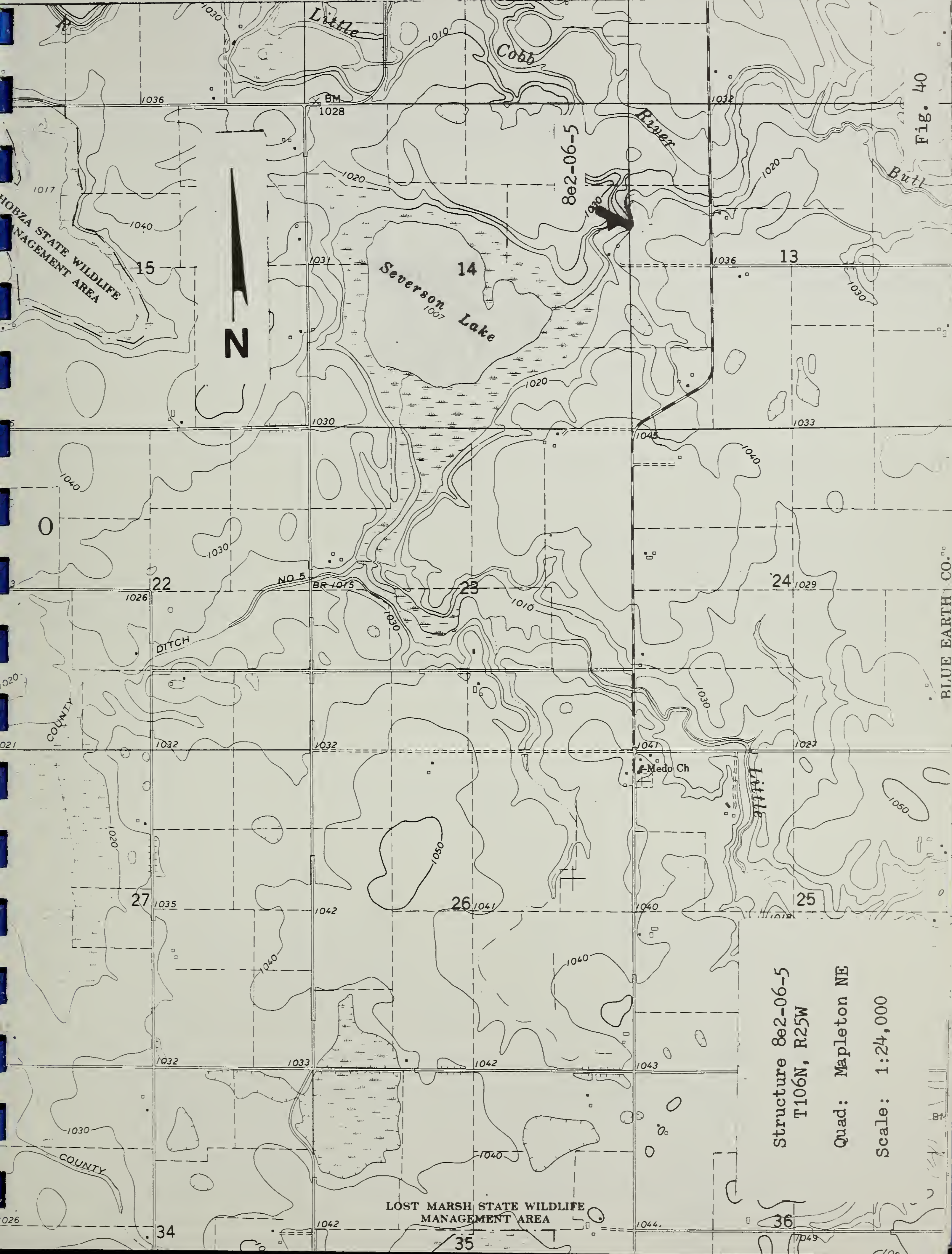


Fig. 40

Structure 8e2-06-5
T106N, R25W
Quad: Mapleton NE
Scale: 1:24,000

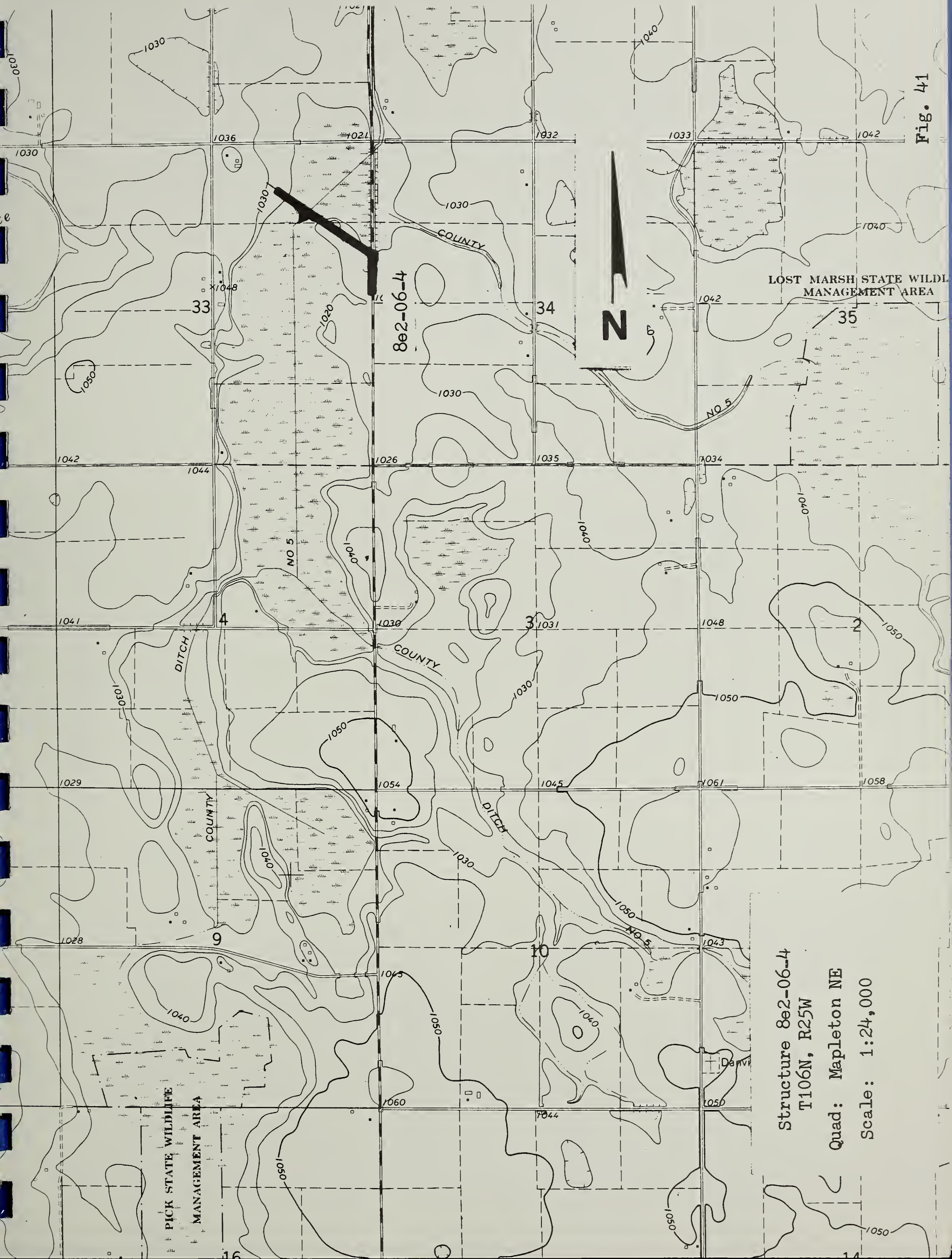


Fig. 41

Structure 8e2-06-4
T106N, R25W
Quad: Mapleton NE
Scale: 1:24,000

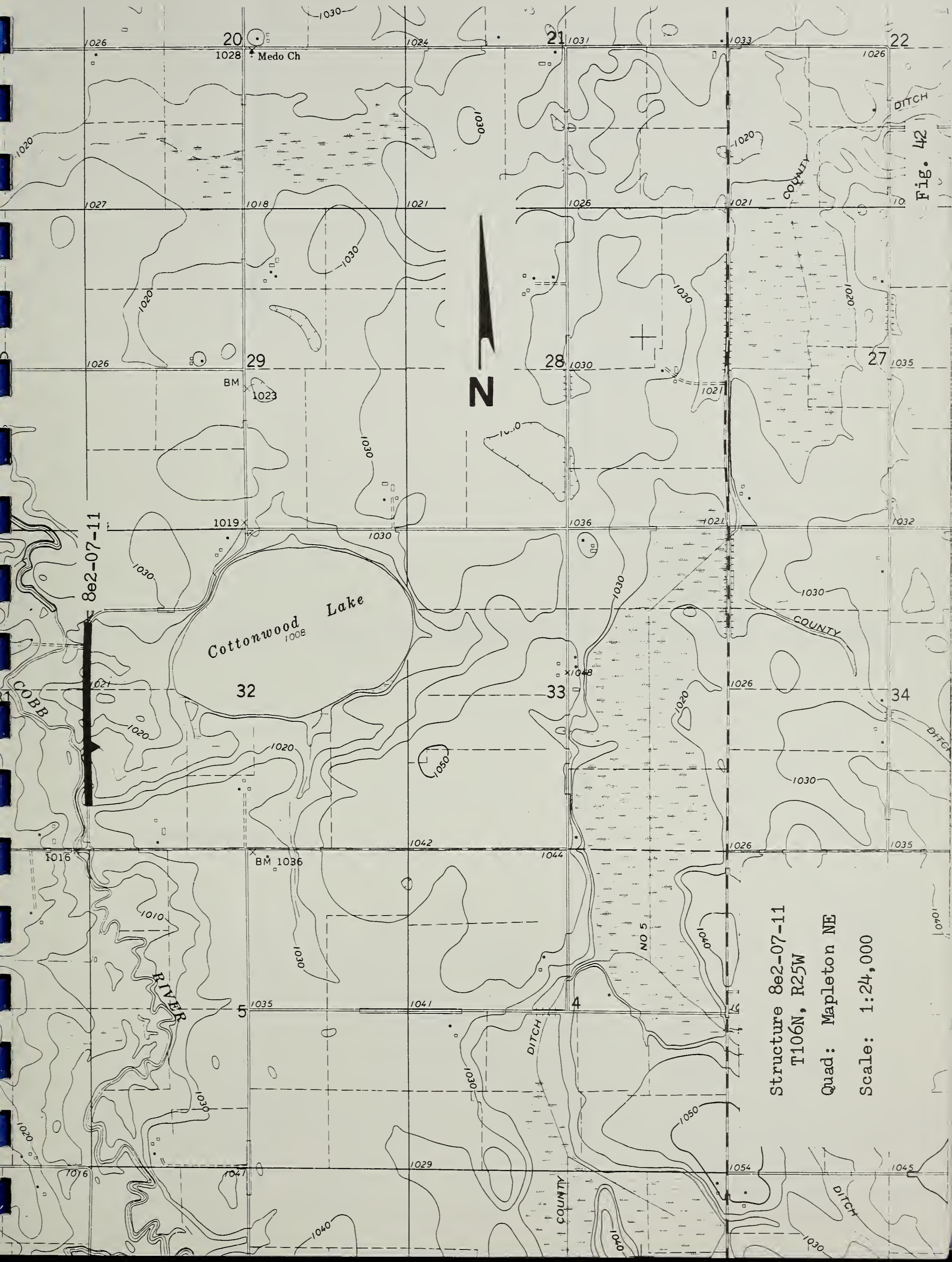


Fig. 42

Structure 8e2-07-11
T106N, R25W

Quad: Mapleton NE

Scale: 1:24,000

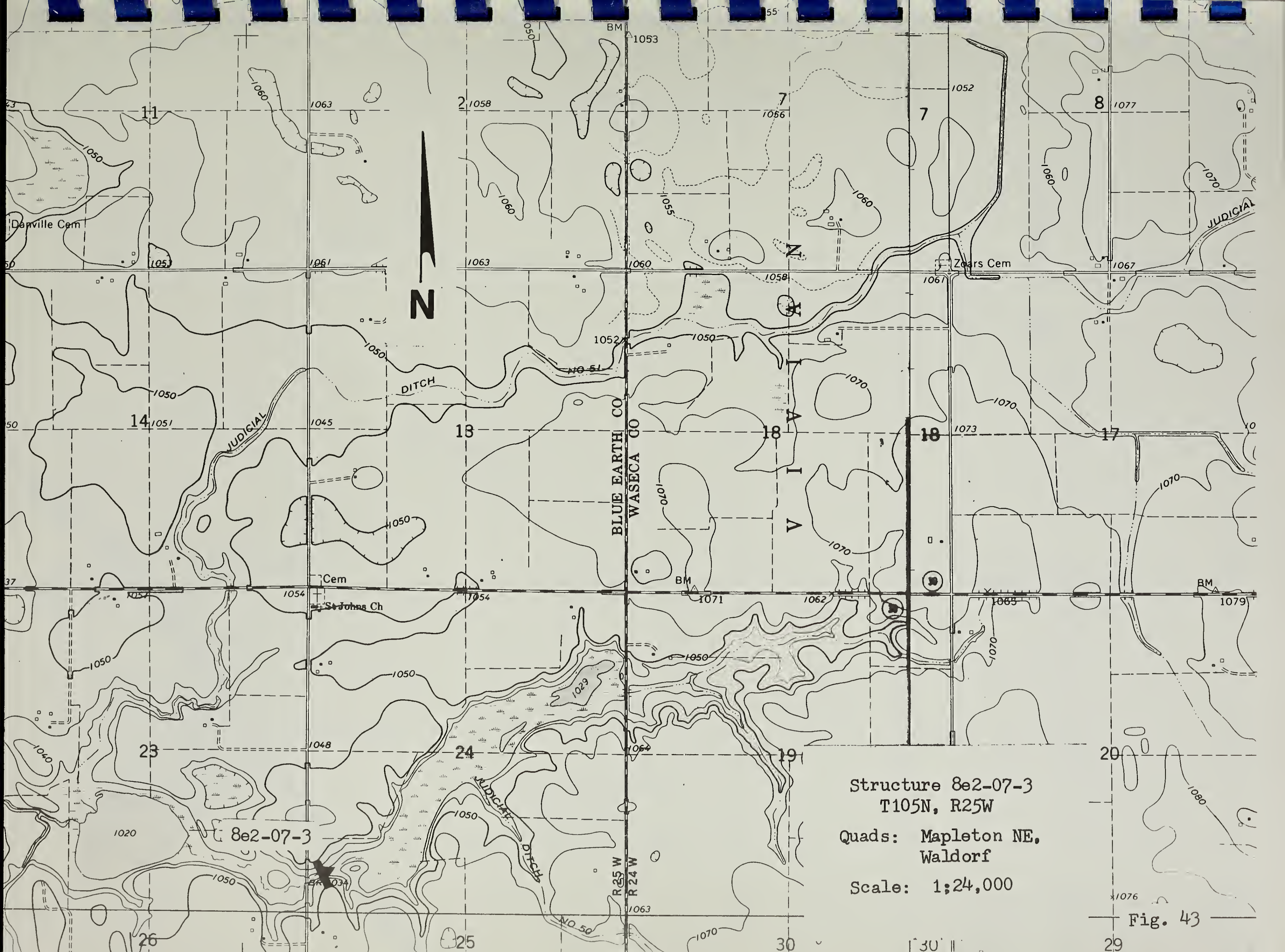
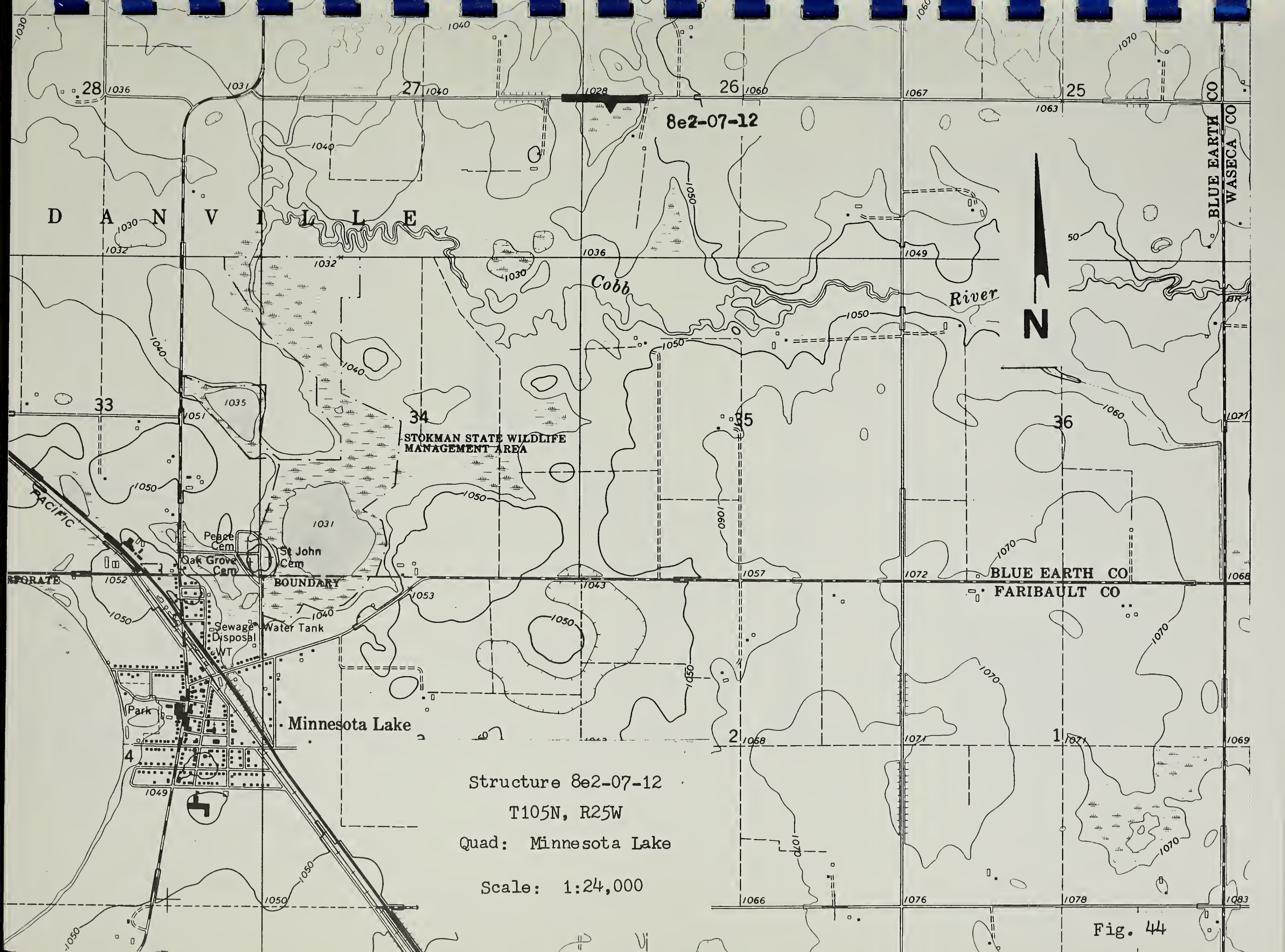

Danville Cem
Zoars Cem
St Johns Ch
Cem
BLUE EARTH CO
WASECA CO
JUDICIAL
DITCH
NO 51
NO 50
N
8e2-07-3
Structure 8e2-07-3
T105N, R25W
Quads: Mapleton NE,
Waldorf
Scale: 1;24,000
R25W
R24W

Fig. 43



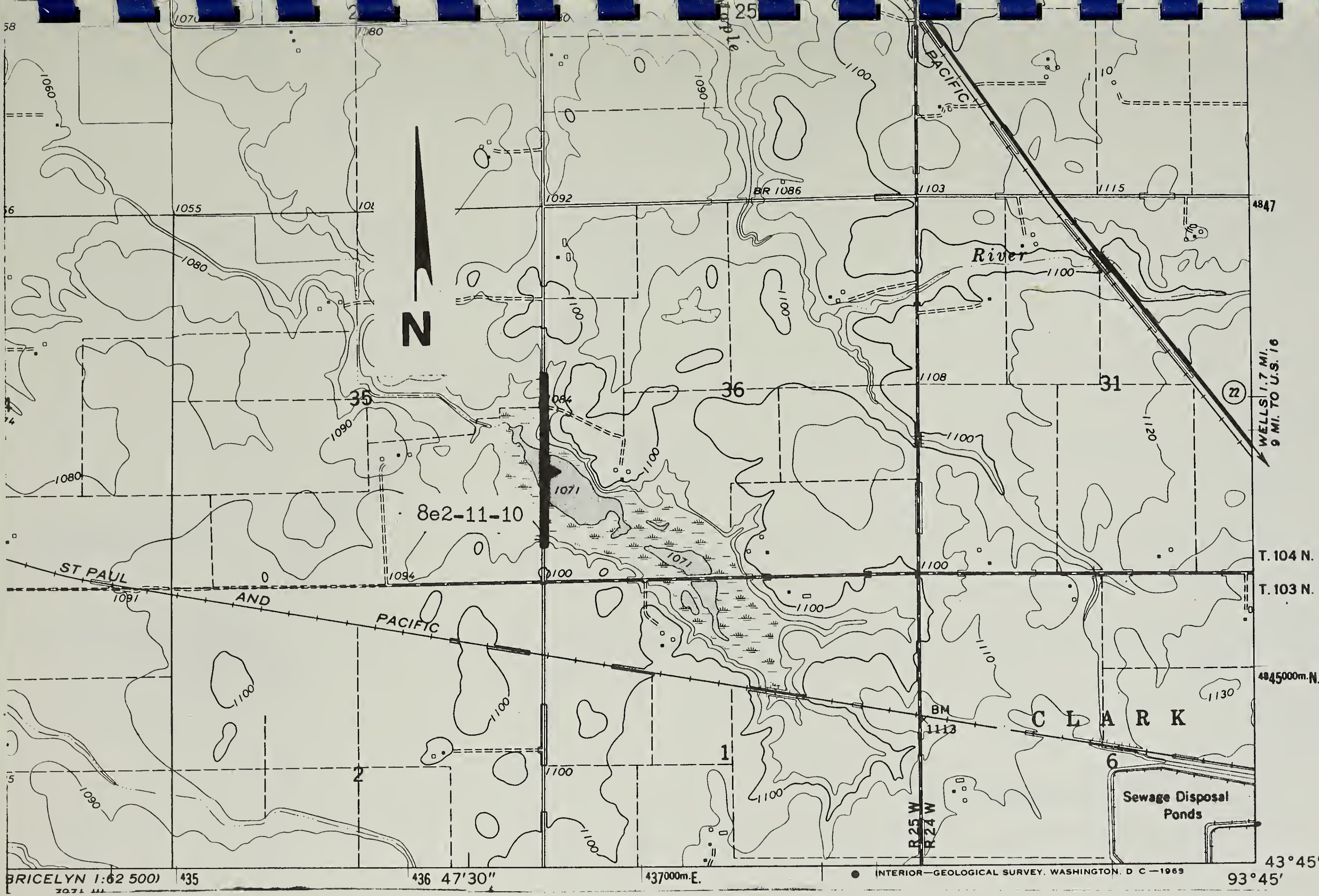
Structure 8e2-07-12

T105N, R25W

Quad: Minnesota Lake

Scale: 1:24,000

Fig. 44



Structure 8e2-11-10

T104N, R25W

Quad: Minnesota Lake

Scale: 1:24,000

Fig. 45

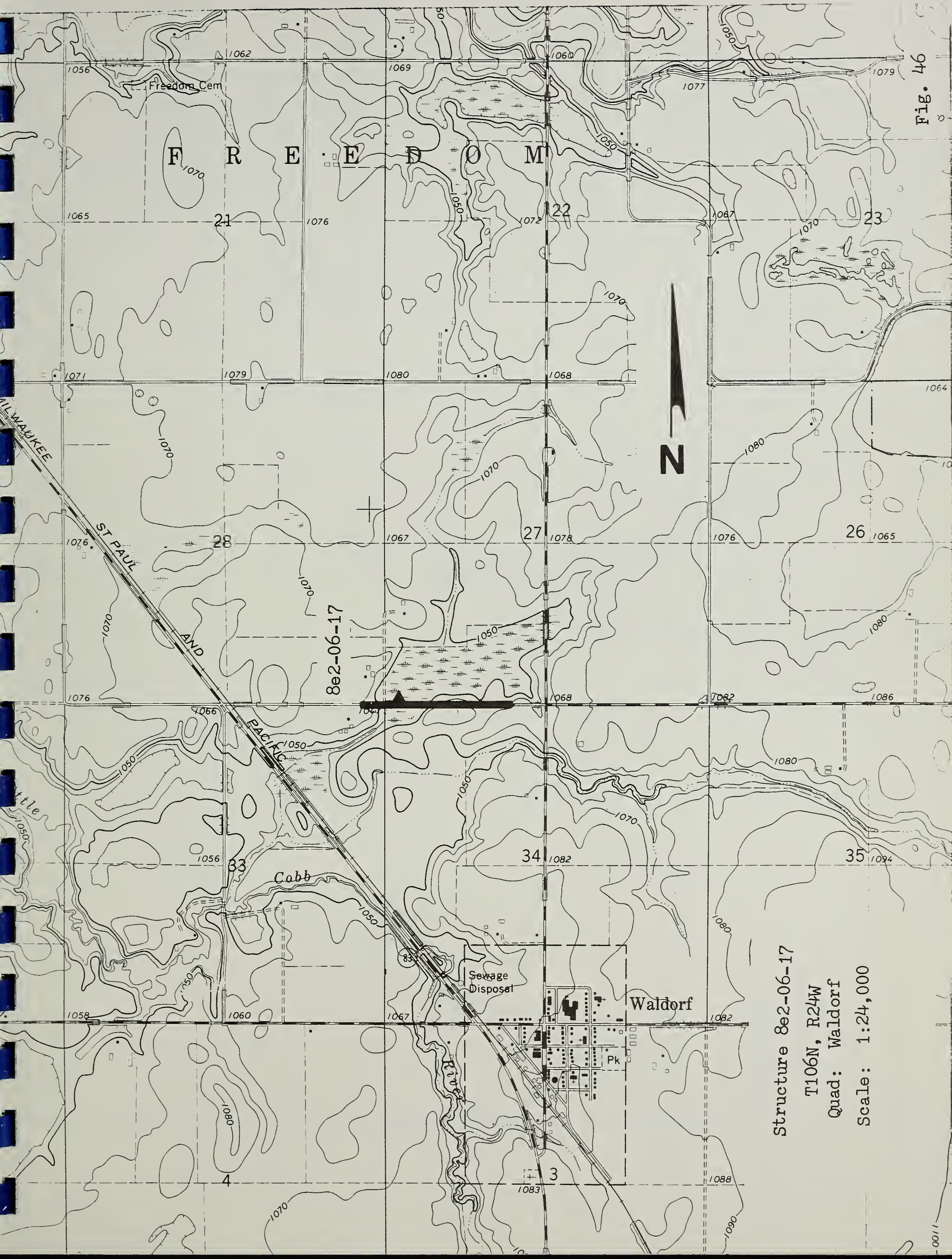


Fig. 46

Structure 8e2-06-17
T106N, R24W
Quad: Waldorf
Scale: 1:24,000

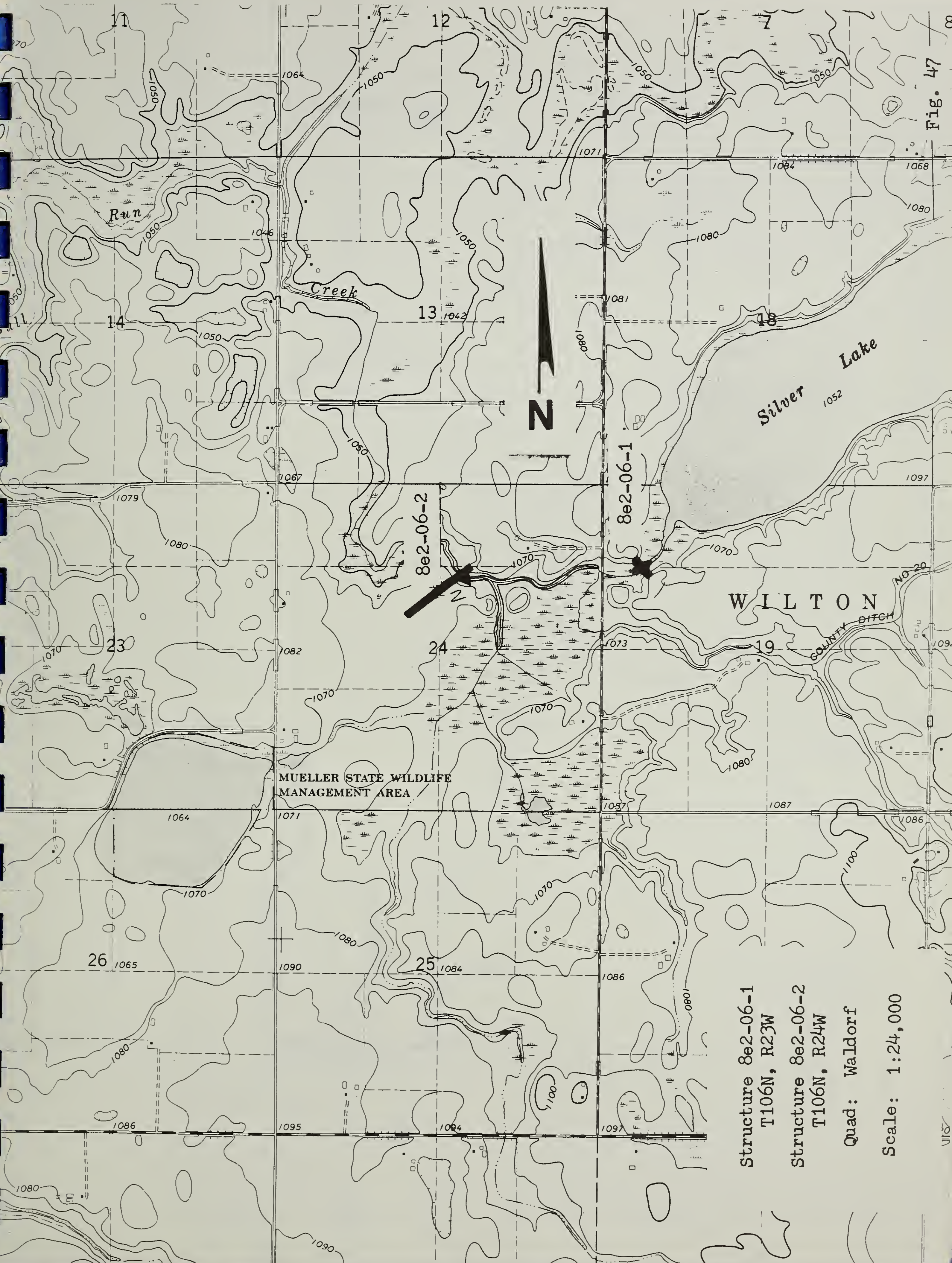
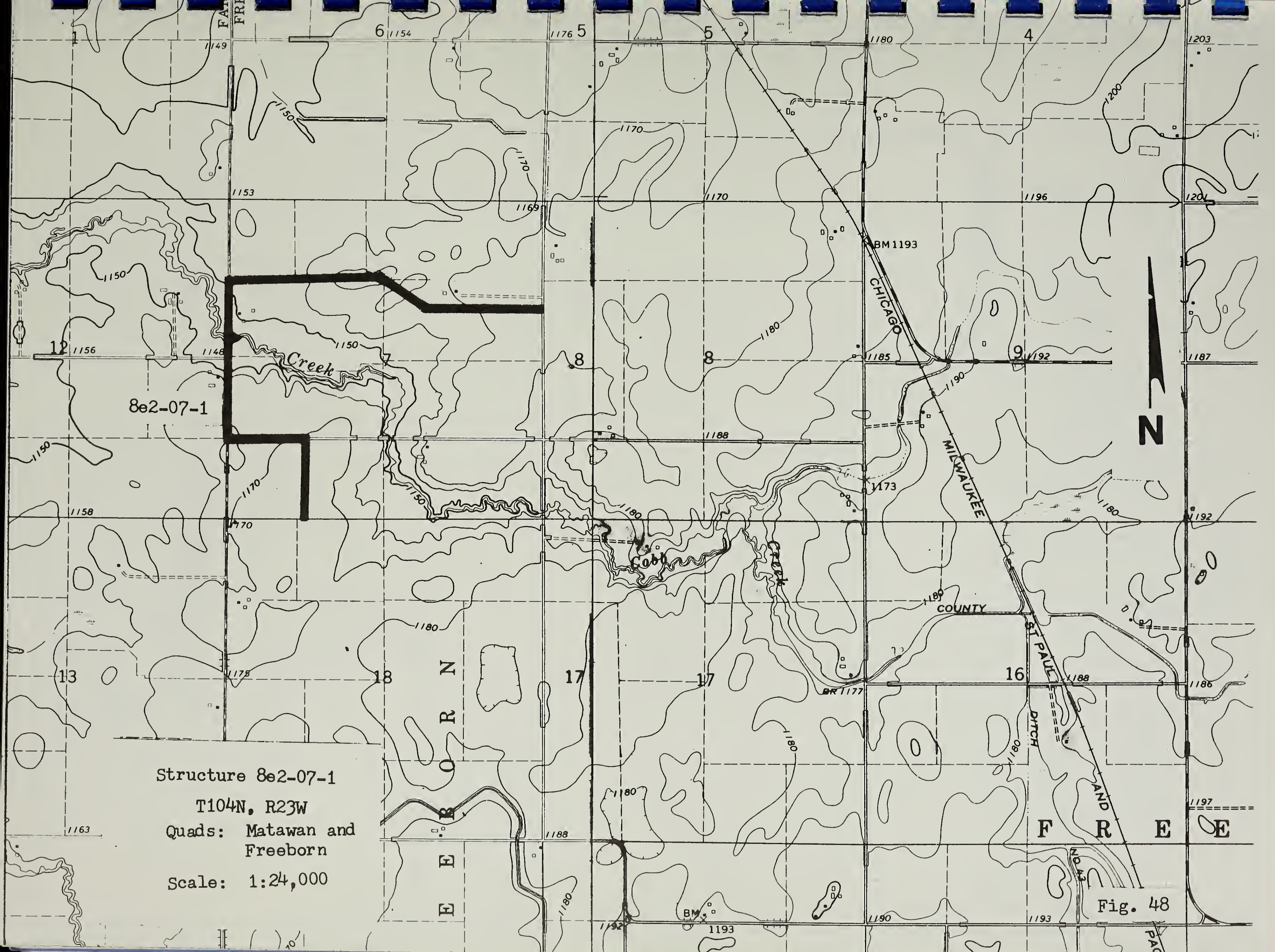


Fig. 47

Structure 8e2-06-1
T106N, R23W
Structure 8e2-06-2
T106N, R24W
Quad: Waldorf
Scale: 1:24,000



Structure 8e2-07-1
T104N, R23W
Quads: Matawan and Freeborn
Scale: 1:24,000

Fig. 48

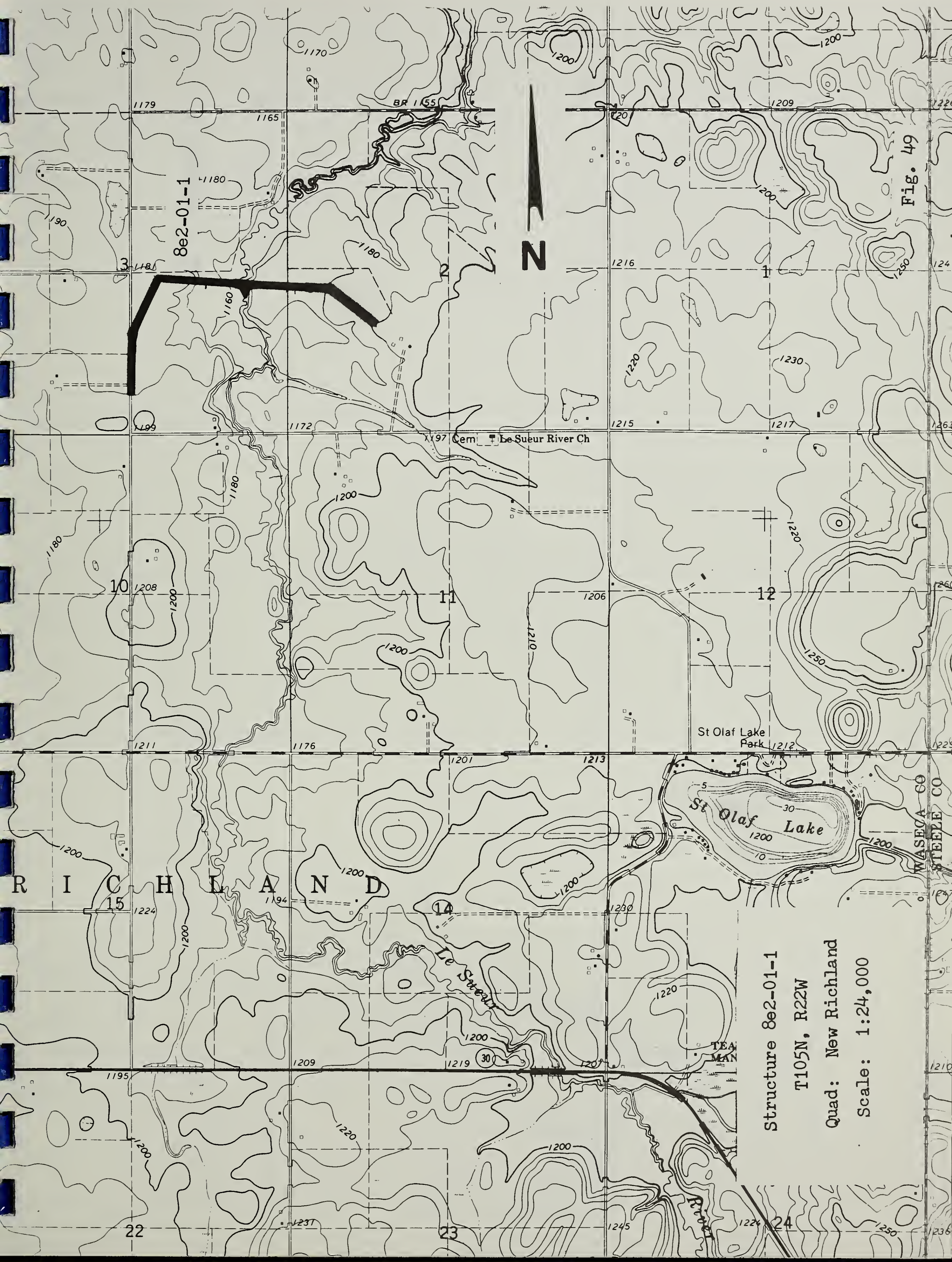

8e2-01-1
N
Le Sueur River Ch
Cem
St Olaf Lake Park
St Olaf Lake
Le Sueur River
R I C H L A N D
WASECA CO
STEELE CO
1
2
3
10
11
12
14
15
22
23
24
Structure 8e2-01-1
T105N, R22W
Quad: New Richland
Scale: 1:24,000
Fig. 49

Fig. 50

Structure 8e2-01-17
T105N, R21W
Quads: New Richland and Hope

Scale: 1:24,000

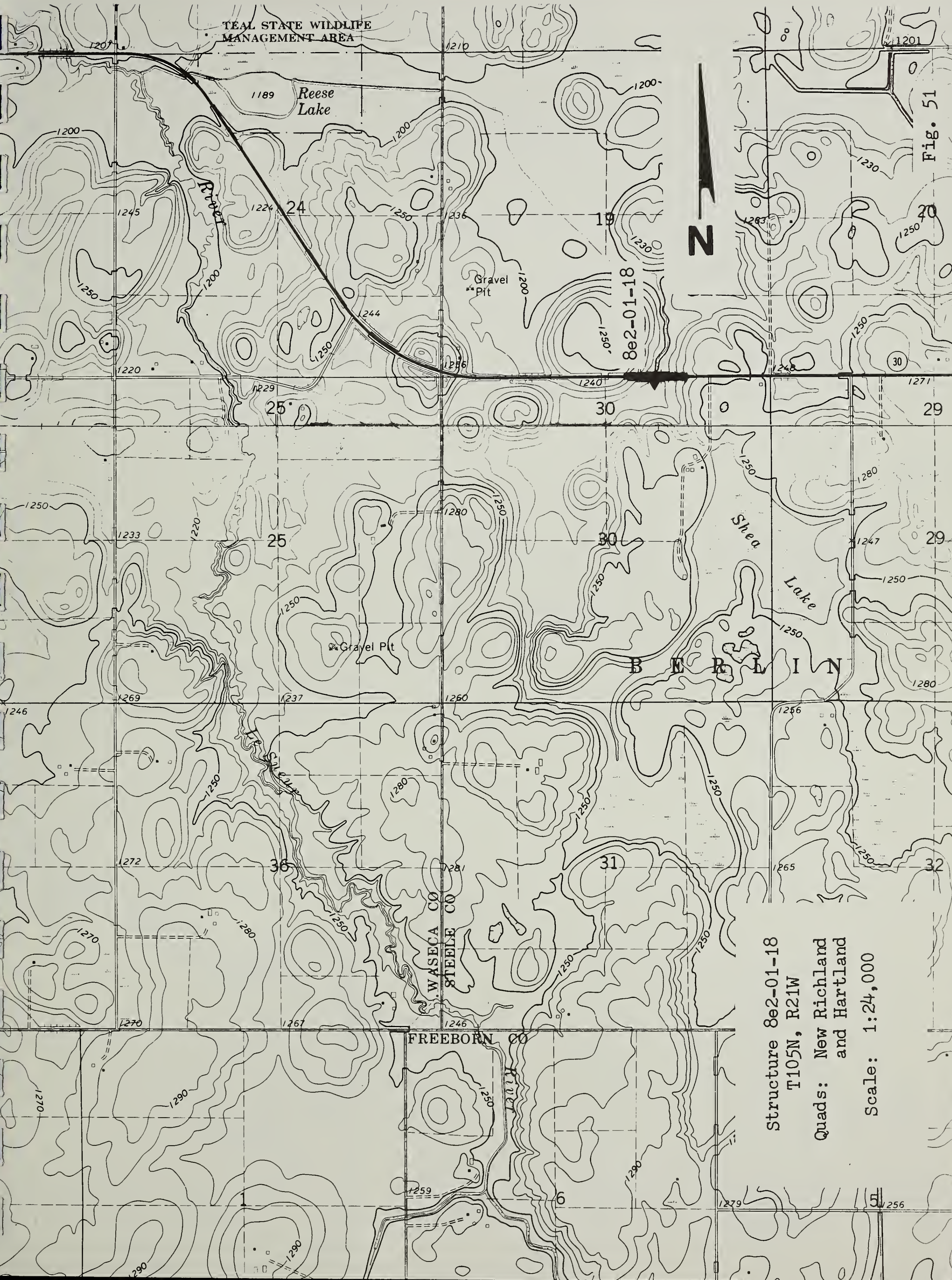


Fig. 51

Structure 8e2-01-18
T105N, R21W
Quads: New Richland
and Hartland

Scale: 1:24,000

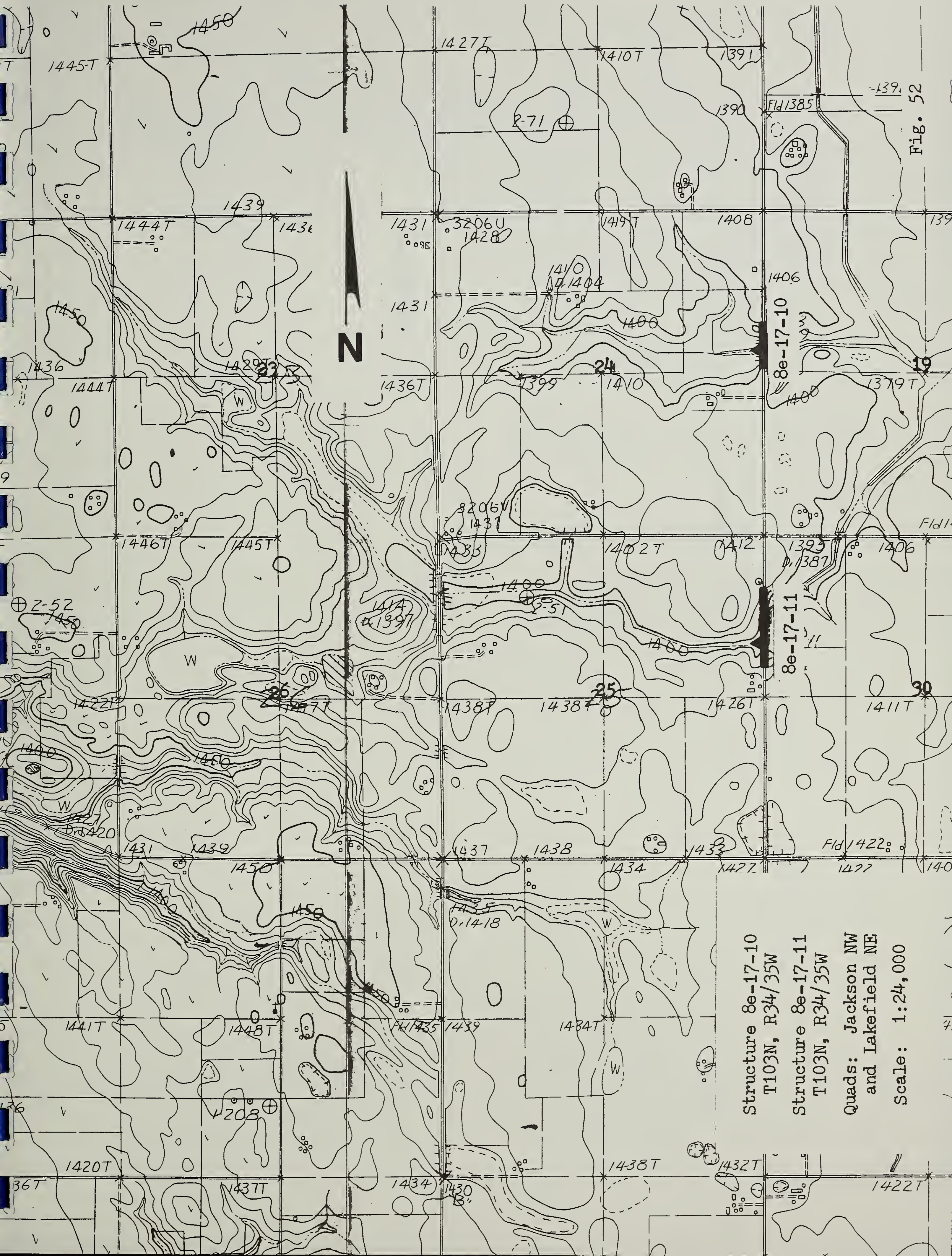


Fig. 52

Structure 8e-17-10
T103N, R34/35W
Structure 8e-17-11
T103N, R34/35W
Quads: Jackson NW
and Lakefield NE
Scale: 1:24,000

Fig. 53

Structure 8e-17-12
T103N, R33W

Quad: Jackson NE

Scale: 1:24,000

Fig. 54

Structure 8e-15-10
T103N, R31W
Quad: Sherburn NE
Scale: 1:24,000

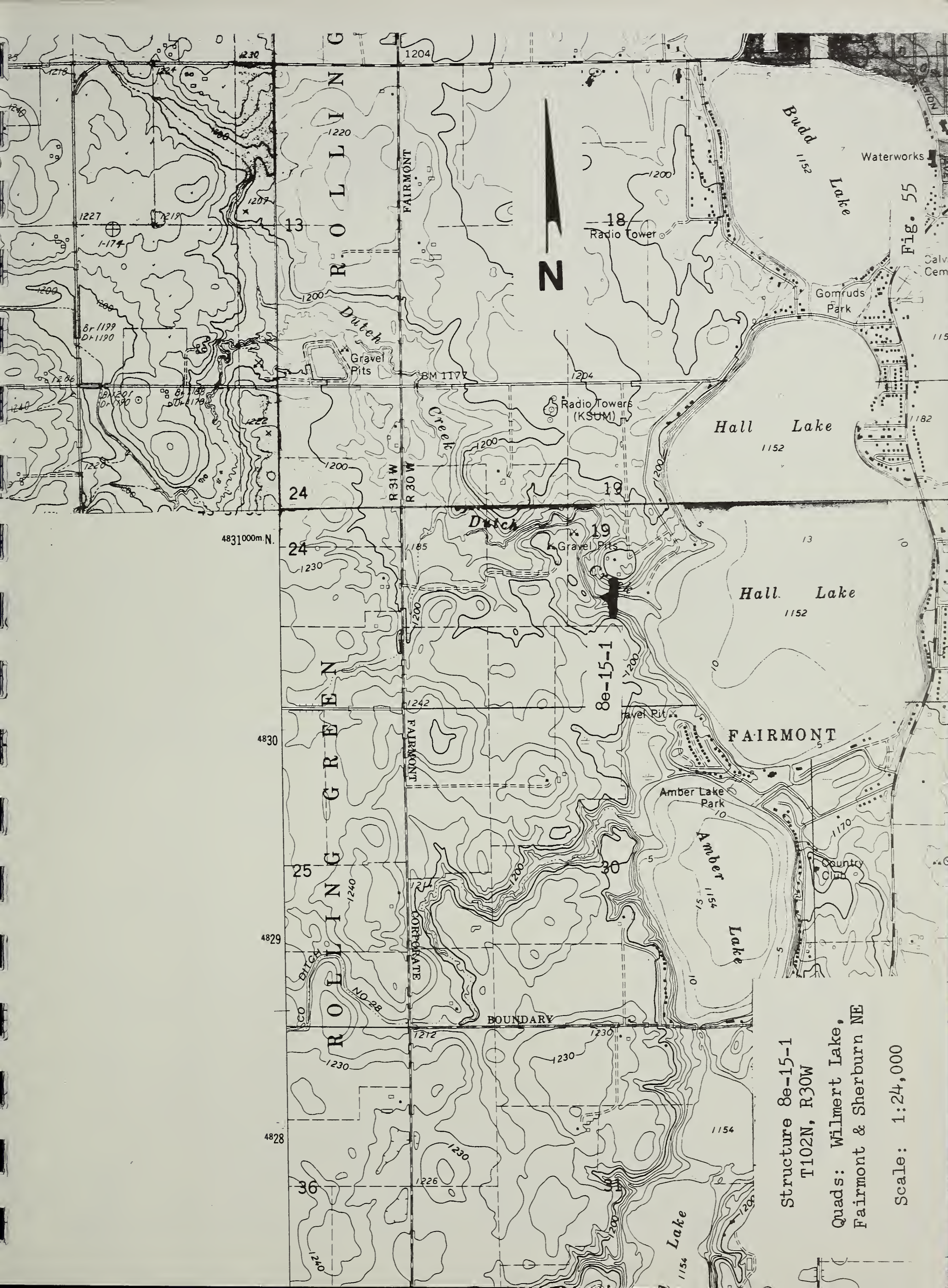


Fig. 55

Structure 8e-15-1
T102N, R30W
Quads: Wilmert Lake,
Fairmont & Sherburn NE
Scale: 1:24,000

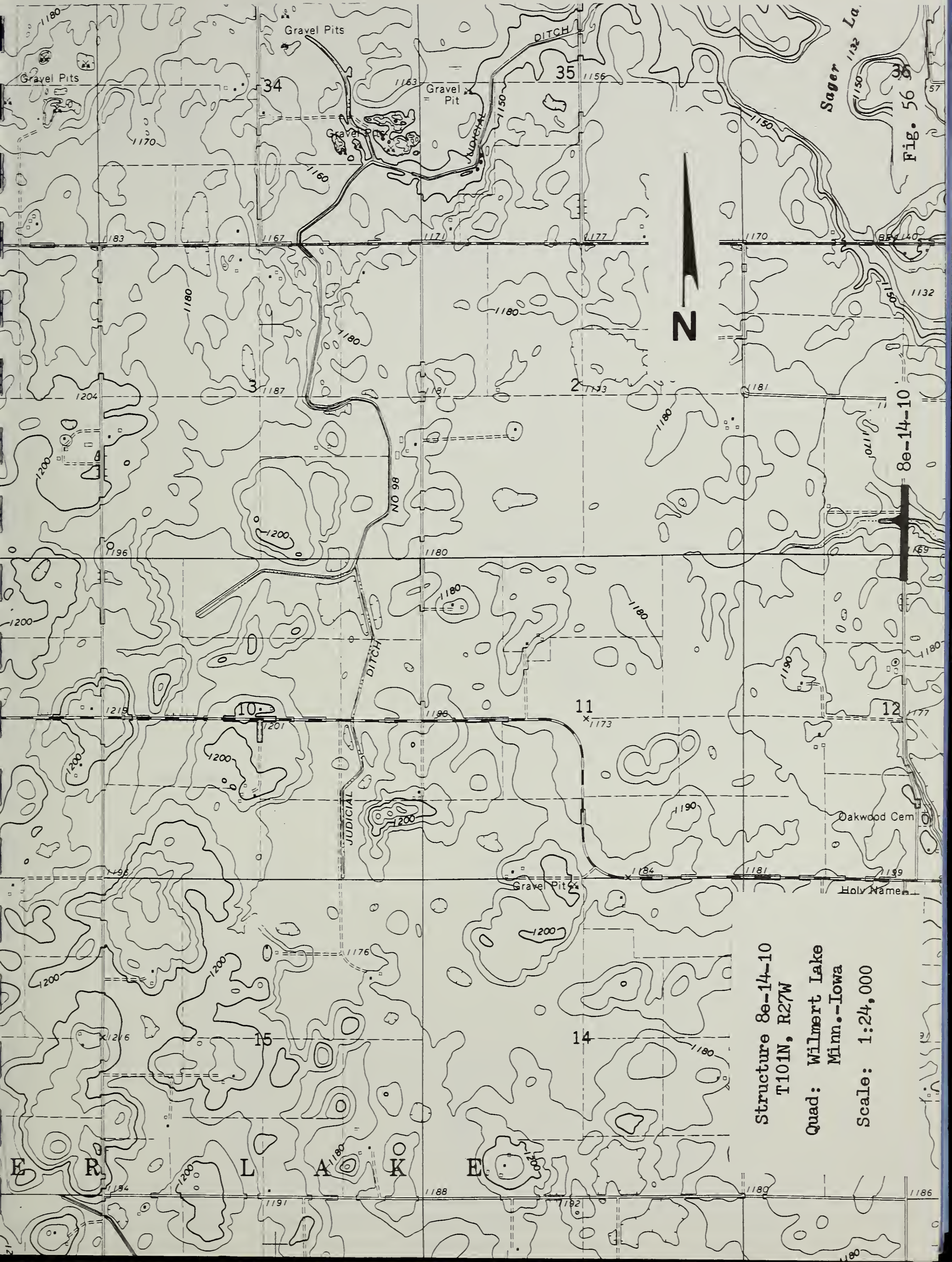
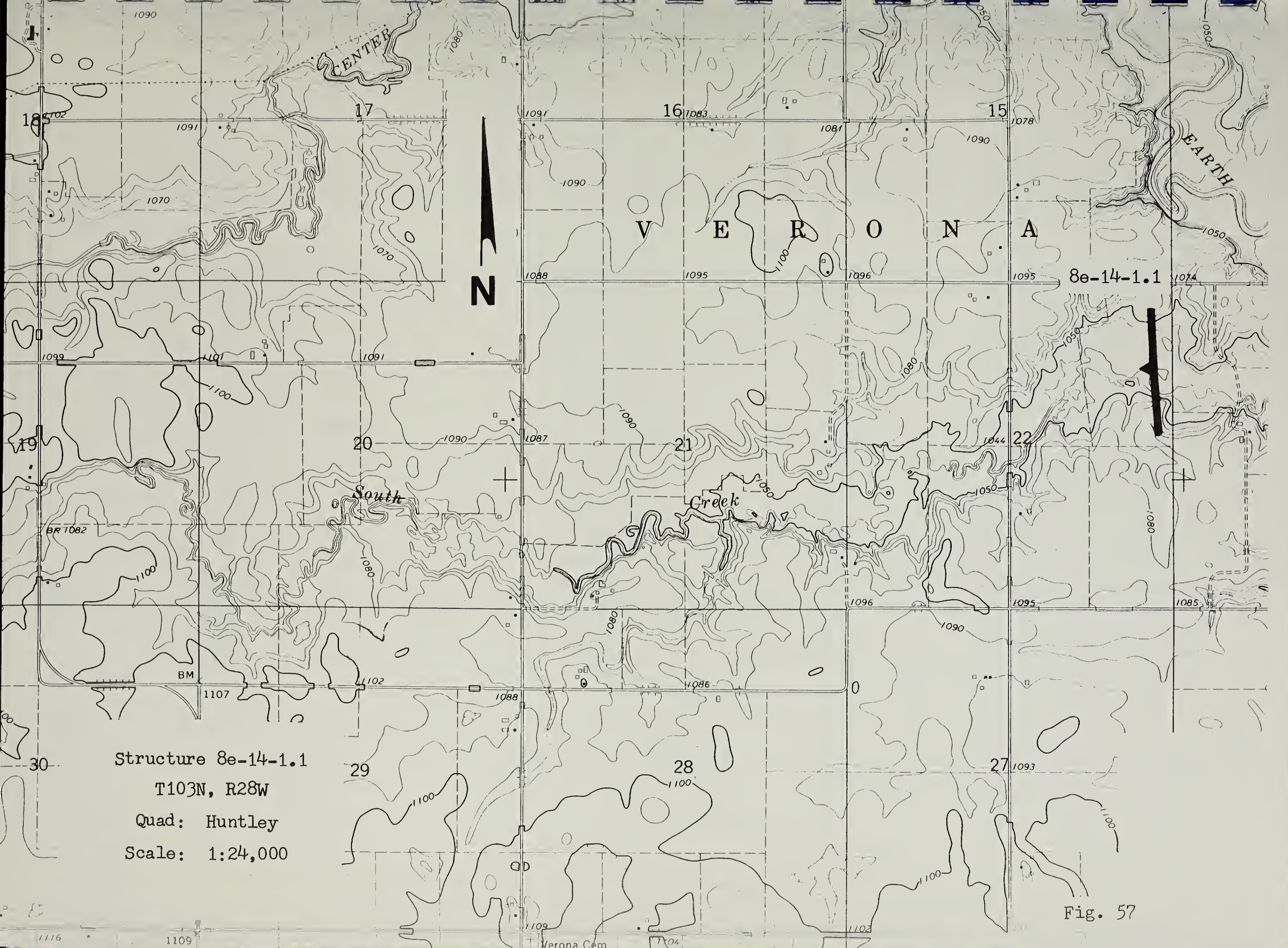


Fig. 56

8e-14-10

Structure 8e-14-10
T101N, R27W
Quad: Wilmert Lake
Minn.-Iowa
Scale: 1:24,000



Structure 8e-14-1.1
T103N, R28W
Quad: Huntley
Scale: 1:24,000

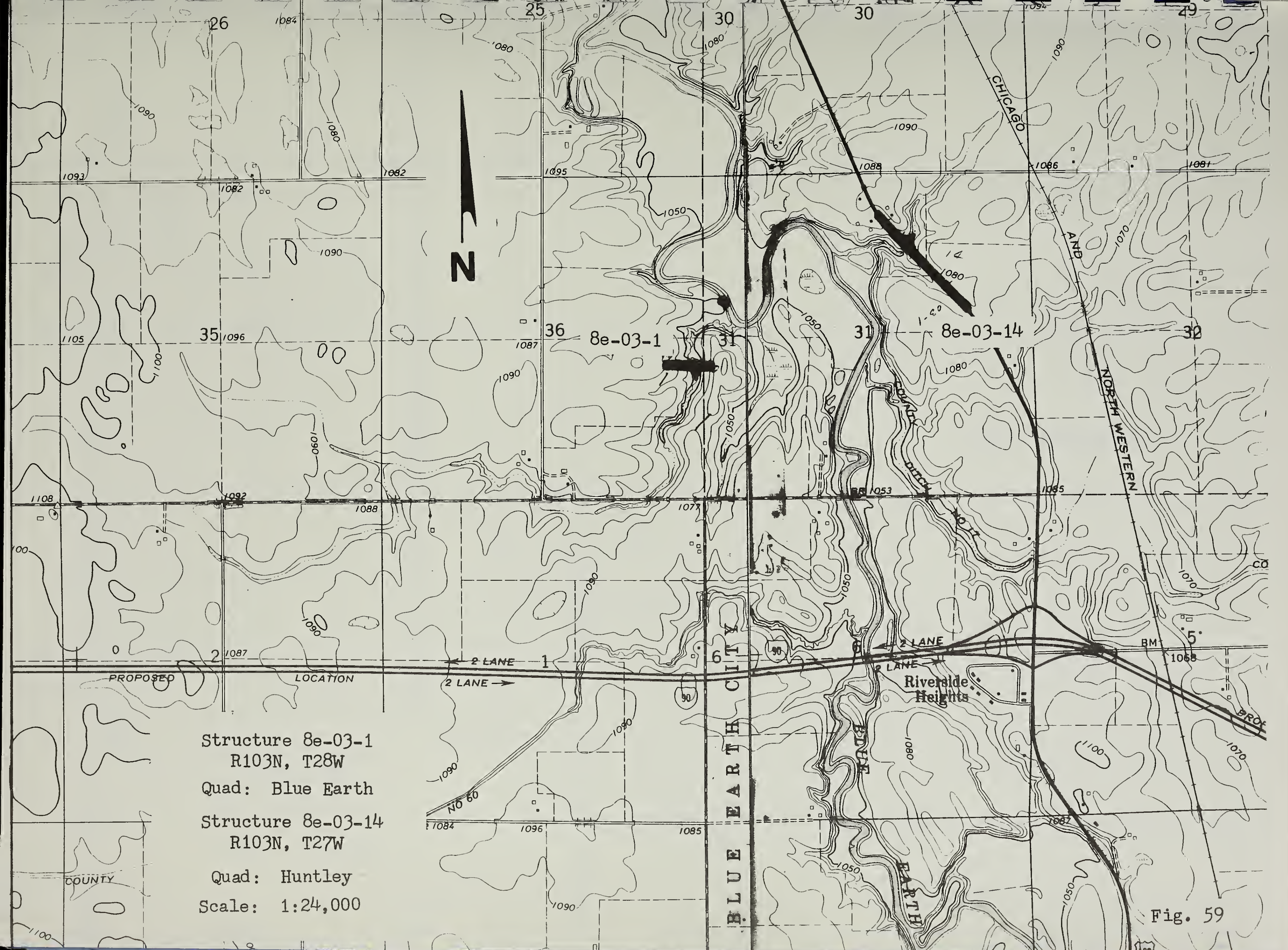
Fig. 57

Structure 8e2-09-10
T103N, R27W

Quad: Blue Earth

Scale: 1:24,000

Fig. 58



Structure 8e-03-1
R103N, T28W
Quad: Blue Earth
Structure 8e-03-14
R103N, T27W
Quad: Huntley
Scale: 1:24,000

Fig. 59

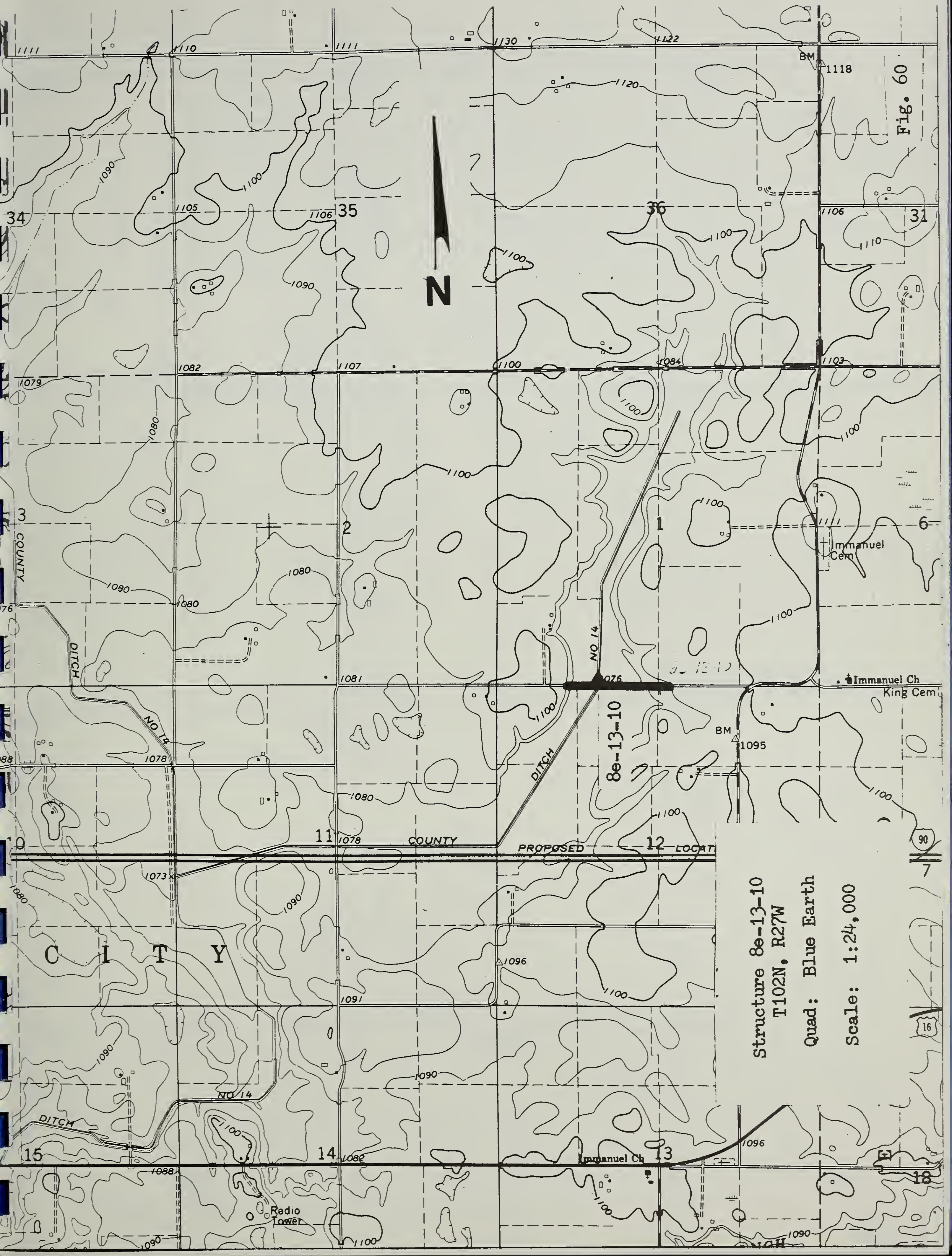


Fig. 60

Structure 8e-13-10
T102N, R27W
Quad: Blue Earth
Scale: 1:24,000

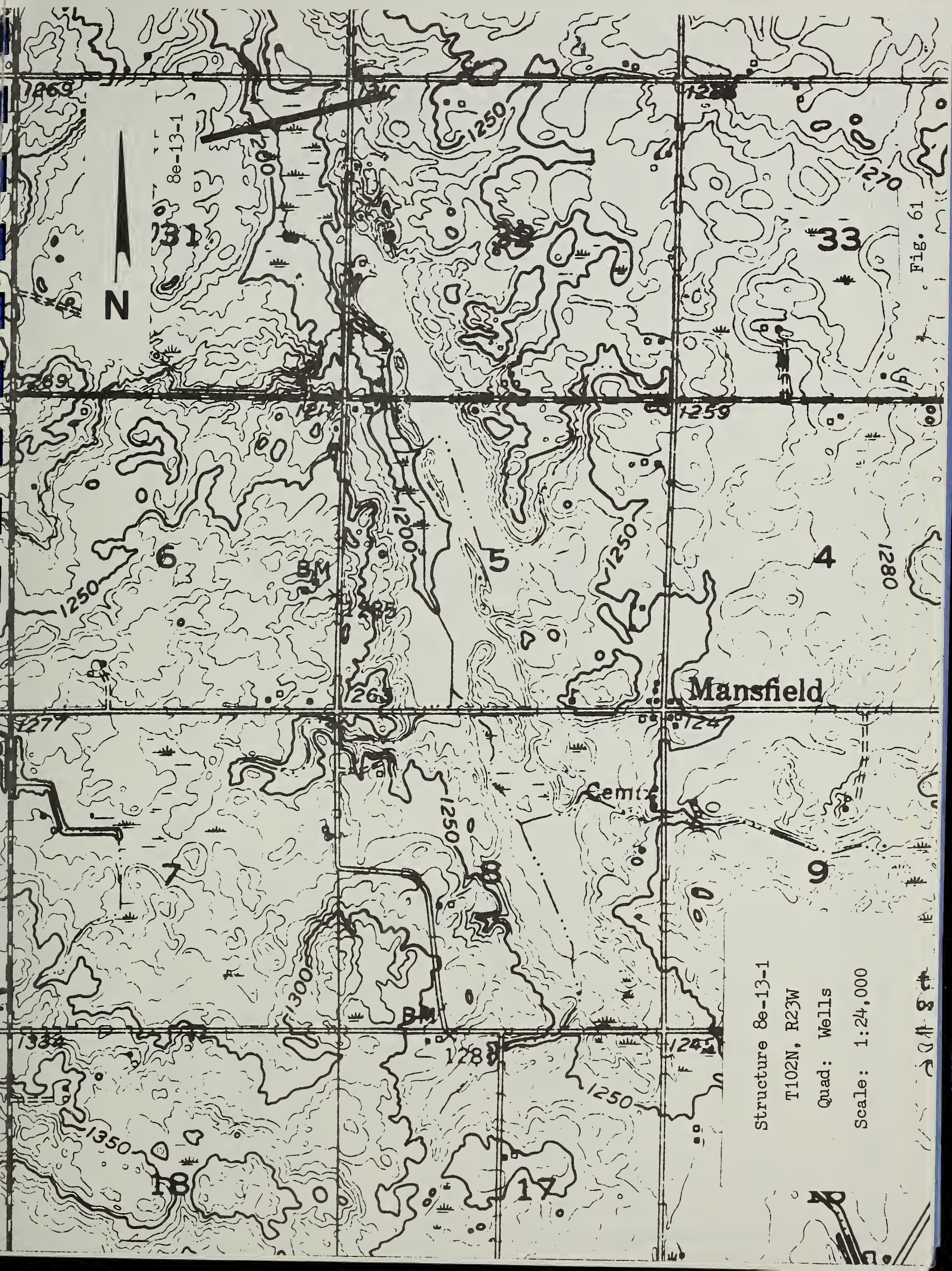
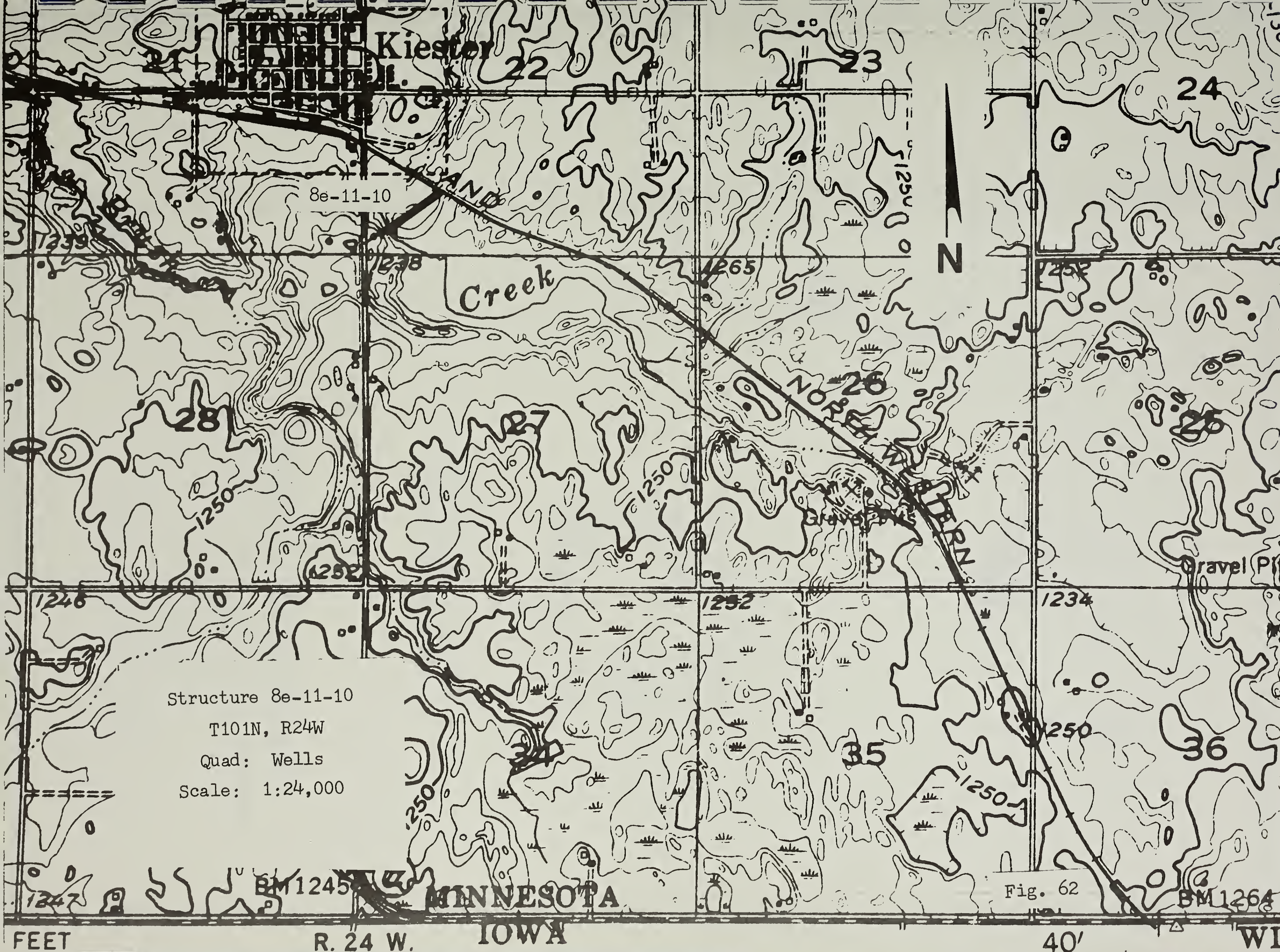


Fig. 61

Structure 8e-13-1
T102N, R23W
Quad: Wells
Scale: 1:24,000



Structure 8e-11-10
T101N, R24W
Quad: Wells
Scale: 1:24,000

Fig. 62


U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
BROWN
BLUE EARTH
LE SUEUR
WASECA
STEELE
COTTONWOOD
WATONWAN
JACKSON
MARTIN
FARIBAULT
FREEBORN
EMMET
KOSSUTH
WINNEBAGO
MINNESOTA
IOWA
MINNESOTA RIVER
MANKATO
MINN·UM·MINN-8e1
MINN·UM·MINN-8e2
MINN·UM·MINN·8e
BASE LEGEND
BASIN BOUNDARY
STATE BOUNDARY
COUNTY BOUNDARY
DRAINAGE
LAKE
TOWN
COUNTY SEAT
SUBBASIN BOUNDARY
CNI WATERSHED BOUNDARY
LEGEND
SITES INVESTIGATED
SITES INVESTIGATED THAT HAVE STORAGE
POTENTIAL FOR FLOOD PREVENTION
UPSTREAM RESERVOIR SITES
Study Area 1 - BLUE EARTH RIVER SUBBASIN
of the
MINNESOTA RIVER BASIN
portion of the
SOUTHERN MINNESOTA RIVERS BASIN STUDY
MINNESOTA, SOUTH DAKOTA, AND IOWA
SOURCE:
BASE MAP 5,S-29,226 AND INFORMATION FURNISHED FROM FIELD TECHNICIANS.
TRANSVERSE MERCATOR PROJECTION
SCALE 1/500,000
1-3-72
5,S-29830

APPENDIX NO. 2
INVENTORY REPORT

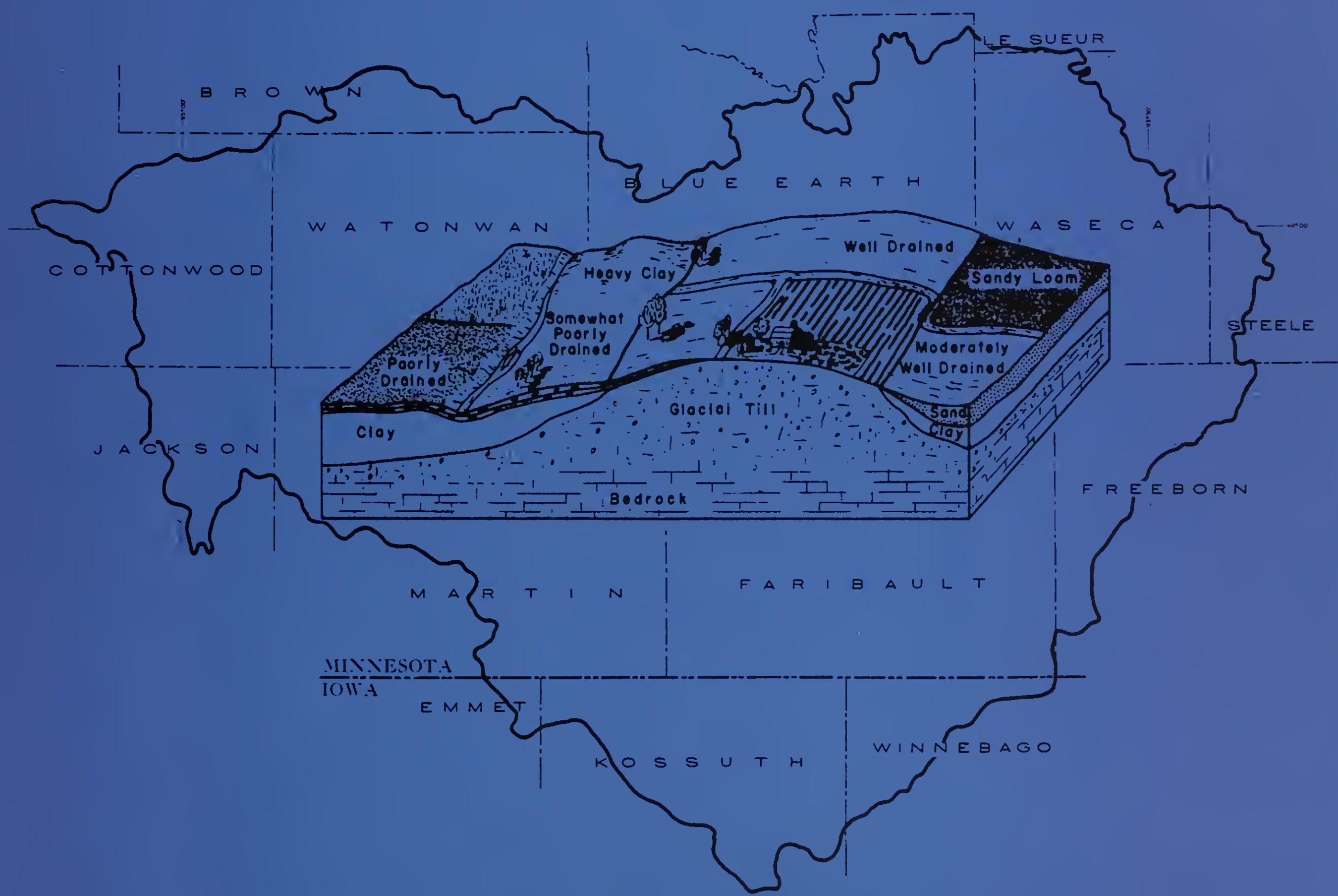
BLUE EARTH RIVER SUBBASIN

of the

MINNESOTA RIVER BASIN

portion of the

SOUTHERN MINNESOTA RIVERS BASIN STUDY



SOIL ASSOCIATION DESCRIPTIONS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

1971

SOIL ASSOCIATION DESCRIPTIONS

BLUE EARTH RIVER SUBBASIN

The Blue Earth River Subbasin relief is controlled in part by underlying bedrock and in part by thick glacial drift. Relief is comprised of 42 percent gently rolling, 4 percent rolling, 13 percent level topped hills with smooth side slopes, 37 percent gently undulating ground moraines and flat glacial lake features, and 4 percent outwash valley trains and alluvium. Closed depressions and dead lakes are common features. First and second order streams are few. Most streams, major and minor, flow in deep entrenchments relic from glacial torrents and erosional eras more intense than present. Most streams, particularly the major ones, are underfit and few floods have volume beyond the alluvial bottom. The present alluvial bottom probably outlines most of the flood limits in the past several thousand years. The Blue Earth, Le Sueur and Watonwan Rivers have a series of abandoned bottoms and terraces high above the present flow. Additionally, a buried floodplain exists below the present floodplain. These record a most varied stream history since 10,000 B.C. Flooding is in two forms: sustained high flow from prolonged rains and snowmelt over the whole watershed, and floods of rapid rise and subsidence from side valley ravines and intermittent streams.

Soils occur in an intermingled pattern and most fields are a complex of several or more soils. Over 90 percent of the land is in farms and about 90 percent is in cropland. Corn and soybeans are the principal crops.

The following sections of this report describe the physiography and soils of each soil association delineated in the subbasin.

I. Blue Earth River Subbasin - Area 1

A. Physiography

1. Coteau Slope

This area represents about 1 percent of the Blue Earth River Subbasin. This land form is stepped level, northeasterly facing slope 5 to 10 miles wide and over 100 miles long.

Elevation differences are commonly on the order of several hundred feet within a distance of 5 to 7 miles. The slope is crossed at regular intervals by sharply entrenched ravines with few side ravines. Relief within the area is commonly gently undulating with steep scarp slopes along the ravines, but these are less pronounced in the area within the Blue Earth River Subbasin.

Formation of this landform supports several postulations. One would explain it as a till plain truncated by glacial ice. The ravines formed during melting of the dead ice feature up slope and were further incised by past glacial erosion. Outwash or valley train features are very few or nonexistent over large areas.

Sediment yields are estimated to be near 100 tons per square mile per year.

B. Soils

The dominant soils are Canisteo, Clarion, Glencoe, Nicollet and Webster. Minor soils are Storden and Terril.

In some places quartzite bedrock is within 5 feet of the surface. A typical section has about 40 percent poorly drained soils with extremes of 35 to 45 percent.

Canisteo are poorly and very poorly drained loamy calcareous soils. They formed in glacial till. They occupy 2 to 10 acre rims, depressions and slight rises and over 150 acres of broad flats. Where undrained, the perched water table is at 1 to 1½ feet during parts of the growing season. Where drained, the rooting zone is commonly 3 to 4 feet deep. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C, undrained; B, drained.

Clarion are well drained, slightly to medium acid loamy soils formed in glacial till. They occupy 3 to 20 acre irregular knolls. The rooting zone is unrestricted in the upper 4 feet. estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Glencoe are very poorly drained, slightly acid to mildly alkaline soils. They formed in glacial pediment 3 to 6 feet thick over glacial till. They occupy 1 to 5 acre depressions and 5 to 40 acre long, winding, low gradient drainageways. Where undrained, a perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group D, undrained; C, drained.

Nicollet are moderately well drained to somewhat poorly drained, slightly or medium acid loamy soils. They occupy 2 to 15 acre low knolls. They formed in glacial till. A perched water table is at 3 to 5 feet for short periods but in places is near 1½ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet except for the perched water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Webster are poorly drained, neutral or slightly acid loamy soils formed in glacial till. They occupy 10 to 200 acre or more broad nearly level slopes and 3 to 10 acre narrow drainageways. Where undrained, the perched water table is at 1 to 3 feet. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C, undrained; B, drained.

Storden are well drained, calcareous loamy soils. They formed in glacial till. They occupy ½ to 1 acre convex slopes in complex

with the Clarion soils. The rooting zone is restricted by the high concentrations of lime carbonates affecting plant nutrition or by limited rooting zone moisture due to slope form. Estimated saturated permeability of .63 to 2.0 inches per hour (could be lower due to weak structure and high concentration of fine lime carbonates). Hydrologic group B.

Terril are well and moderately well drained, slightly acid or neutral loamy soils. They formed in thick erosional pediment along the lower concave slopes and occupy long narrow strips at the base of the Clarion slopes. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

II. Blue Earth River Subbasin - Area 2

A. Physiography

1. Undulating Loamy Ground Moraines and Ice Disintegration Features

This area represents about 5 percent of the Blue Earth River Subbasin. The dominant landform is aligned, narrow crested ridges and unaligned low knolls interspersed with narrow swales. Crests rise from 5 to 10 feet above their base. Slopes are short, 40 to 100 feet; the shoulder slope is convex; the back slope is concave. The narrow crests are but segments of adjoining convex slopes. Recency of deposition, climate and the base level of major streams have limited the development of first and second order streams. This normal landscape development has been preempted by ditching and extensive tiling.

The surficial material is commonly a loam texture. This landscape seemingly formed beneath advancing ice and was mantled by ablation till high in content of shale.

This area begins abruptly at the base of the coteau slope in southwestern Minnesota, and extends to the north and east where it is bounded by lake basins and end moraines or merges into

level ground moraine.

Sediment yields are estimated to be less than 10 tons per square mile per year.

B. Soils

The dominant soils are Canisteo, Clarion, Glencoe, Lucan, Nicollet, Storden, Webster, Peat and Muck. Minor soils are Harps and Terril.

A typical section has about 50 percent poorly drained soils with extremes ranging from 40 to 60 percent.

Canisteo are poorly and very poorly drained, loamy, calcareous grassland soils. They formed in glacial till. They occupy 2 to 10 acre rims of depressions and slight rises and broad flats to 150 acres. Where undrained, the perched water table is at 1 to $1\frac{1}{2}$ feet during parts of the growing season. Where drained, the rooting zone is commonly 3 to 4 feet deep. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C, undrained; B, drained.

Clarion are well drained, slightly or medium acid, loamy grassland soils. They formed in glacial till. They occupy 3 to 20 acre irregular knolls and ridge crests. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Glencoe are very poorly drained, neutral to mildly alkaline, loamy grassland soils. They formed in glacial pediment 3 to 6 feet thick over glacial till. They occupy 1 to 5 acre depressions and 5 to 40 acre long, winding, low gradient drainageways. Where undrained, a perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability of .63 to 2.0 inches per hour. Hydrologic group D, undrained; C, drained.

Lucan are moderately well to somewhat poorly drained, calcareous, loamy grassland soils. They formed in glacial till. They occupy 2 to 15 acre low knolls. A perched water table is at 3 to 5 feet for short periods and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet but nutrient availability is affected by the high lime content. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Nicollet are moderately well to somewhat poorly drained, slightly or medium acid, loamy grassland soils. They formed in glacial till. They occupy 2 to 15 acre low knolls, a perched water table is at 3 to 5 feet for short periods and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet except for perched water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Storden soils are well drained, calcareous, loamy grassland soils formed in glacial till. They occupy $\frac{1}{2}$ to 5 acres convex slopes and ridge crests. The rooting zone is restricted by high concentrations of lime carbonates affecting plant nutrition or by limited rooting zone moisture due to slope form. Estimated saturated permeability is .63 to 2.0 inches per hour (could be lower due to weak structure and high concentration of fine lime carbonates). Hydrologic group B.

Webster are poorly drained, neutral to slightly acid, loamy grassland soils formed in glacial till and are commonly in complex with Canisteo and Harps soils. They occupy 10 to 200 acre or more broad nearly level slopes and 3 to 10 acre narrow drainageways. Where undrained, the perched water table is at 1 to 3 feet. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C, undrained; B, drained.

Peat and Muck are very poorly drained, slightly acid to calcareous soils. They formed in 18 to 60 inches of reed-sedge vegetative accumulations. They occupy 1 to 5 acre depressions to several hundred acre dead lakes. The underlying material is buried soil in some places and 2 to 15 feet of lake sediments in others. Where undrained, a water table is at or near the surface. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is 5 to 8 inches per hour. Hydrologic group B, C, or D.

Harps are poorly drained, highly calcareous, loamy grassland soils. They occupy 2 to 10 acre rims of depressions and slight rises within the broader flats. Where undrained, the perched water table is at 1 to 1½ feet during the growing season. The rooting zone is near tile depth where drained, but is affected by the high concentration of lime carbonates. Estimated saturated permeability of .63 to 2.0 inches per hour. Hydrologic group C, undrained; B, drained.

Terril are well and moderately well drained, slightly acid or neutral loamy soils. They formed in thick erosional pediment along the lower concave slopes and occupy long, narrow strips at the base of the Clarion slopes. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

III. Blue Earth River Subbasin - Area 3

A. Physiography

1. Alluvium, Kames, Outwash and Valley Trains

This area represents about 4 percent of the Blue Earth River Subbasin. Common landforms are:

a. Alluvium is along all streams and drainageways. Along the major streams, alluvium features are many feet above the present stream flow and buried alluvium exists below the present floodplain alluvium.

b. A series of kames outline disintegration features in east central Faribault County.

c. Outwash - Broad nearly level to gently undulating outwash plains are the dominant landform in this area and includes areas that can be considered deltaic deposits. The largest areas are in northeastern Watonwan and northwestern Blue Earth Counties. Smaller areas are scattered through Faribault and Martin Counties, eastern Waseca and western Steele Counties.

d. Valley train features are identifiable along most of the major stream channels as terrace suites.

Sediment yields are estimated to be less than 10 tons per square mile per year.

B. Soils

Dominant alluvial soils are recent alluvium, Calco, Colo, Comfrey, and unnamed soils number 17, 25, and 95.

Kames are dominantly Dickinson, Dickman, Estherville, Salida and Wadena Soils. In places, these soils are in complex with medium textured glacial drift.

Outwash soils are dominantly Biscay, Darfur, Dickinson, Dickman, Estherville, Fieldon, Grogan, Hanska, Litchfield, Mayer, Rosendale, Sparta and Wadena. The Lake Crystal area is a complex where these soils irregularly mantle and intermingle medium textured ground moraine soils.

Valley train and stream terrace soils are dominantly Biscay, Estherville, Hanska and Wadena.

Alluvial lands are well or moderately well drained, neutral, mixed loamy and sandy textured bottomland. They formed in recent alluvium and occupy long, narrow strips adjacent to the stream channels and alluvial fans from side valley ravines. The perched water table fluctuates with stream flow. These lands are occasionally to frequently flooded.

Biscay are poorly drained, neutral to mildly alkaline, loamy over coarse texture, grassland soils. They formed in 24 to 36 inches of loam over sand and gravel, and they occupy 2 to 100 acre nearly level broad flats and narrow draws. Where undrained, the perched water table ranges seasonally at 1 to 3 feet. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is .63 to 2.0 inches per hour in the loamy upper layers and greater than 6.3 inches per hour in the sandy and gravelly underlying material. Hydrologic group D, undrained; C, drained.

Calco are poorly drained, calcareous, silty grassland soils. They formed in over 40 inches of silty clay loam sediments. They occupy floodplain positions and are occasionally to frequently flooded. The perched water table ranges seasonally from 1 to 3 feet. In places, the water table is controlled by deep outlet ditches or dikes and pumps. The rooting zone is unrestricted to the water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C.

Colo are poorly drained, neutral to mildly alkaline grassland soils. They formed in over 40 inches of silty clay loam sediments. They occupy floodplain positions and are occasionally too frequently flooded. The perched water table ranges seasonally from 1 to 3 feet. In places, the water table is controlled by deep outlet ditches or dikes and pumps. The rooting zone is unrestricted to the water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C.

Comfrey are poorly drained, neutral to mildly alkaline loamy grassland soils. They formed in over 40 inches of clay loam sediments. They occupy floodplain positions and are occasionally to frequently flooded. The perched water table is seasonally 1 to 3 feet. In places, the water table is controlled by deep outlet ditches or dikes and pumps. The rooting zone is unrestricted to the water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C.

Darfur are poorly drained, neutral to mildly alkaline, loamy over sandy, grassland soils. They formed in 20 to 40 inches of fine sandy loam over fine sands commonly stratified with thin strata of loamy or fine sandy loam. They occupy 2 to 100 acres of nearly level broad flats and narrow draws. Where undrained, the perched water table ranges seasonally from 1 to 3 feet. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is 0.6 to 2.0 inches per hour in the loamy upper layers and greater than 6.3 inches per hour in the coarser textured underlying material. Hydrologic group D, undrained; B drained.

Dickinson are somewhat excessively drained, slightly to medium acid, sandy grassland soils. They formed in 20 to 30 inches of sandy loams over sands. They commonly occupy 3 to 20 acre flats and knolls. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is 2.0 to 6.3 inches per hour in the upper sandy layers and greater than 6.3 inches per hour in the sandy underlying material. Hydrologic group A.

Dickman are somewhat excessively drained, medium to slightly acid, sandy grassland soils. They formed in 12 to 26 inches of sandy loam over sands. They commonly occupy 3 to 20 acre flats and knolls. The rooting zone is unrestricted in the upper 60 inches. Estimated saturated permeability of 2.0 to 6.3 inches per hour in the sandy loam layers and greater than 6.3 inches per hour in the sandy underlying material. Hydrologic group A.

Estherville are somewhat excessively drained, medium and slightly acid, sandy over coarse textured, grassland soils. They formed in 15 to 24 inches of sandy loam over sand and gravel. They occupy 3 to 80 acre nearly level to sloping landscapes. The rooting zone is somewhat modified by the sandy and gravelly underlying material. Estimated saturated permeability in the upper sandy loam layers is 2.0 to 6.3 inches per hour and greater than 6.3 inches per hour in the gravelly underlying material. Hydrologic group B.

Fieldon are poorly drained, calcareous, loamy over coarse textured, grassland soils. They formed in 20 to 40 inches of loam over stratified sand and loam. They occupy 2 to 100 acre, nearly level broad flats and narrow draws. Where undrained, the perched water table ranges seasonally at 1 to 3 feet. When drained, the rooting zone is near tile depth. Estimated saturated permeability is 0.6 to 2.0 inches per hour in the loamy upper layers and greater than 6.3 inches per hour in the sandy and gravelly underlying material. Hydrologic group D, undrained; B, drained.

Grogan are well drained, neutral to slightly acid, loamy grassland soils. They formed in 20 to 40 inches of loams over stratified sands and loams. The sand fraction is dominantly very fine and fine. They occupy 3 to 20 acre nearly level to gently rolling landscapes. The rooting zone is unrestricted in the upper 60 inches. Estimated saturated permeability is 2.0 to 6.3 inches per hour in the upper loamy mantle and variable in the stratified underlying material but is estimated to range from 2.0 to greater than 6.3 inches per hour. Hydrologic group B.

Hanska are poorly drained, slightly acid to mildly alkaline, loamy over coarse textured, grassland soils. They formed in 18 to 34 inches of sandy loam or loam sediments over sand. They occupy 3 to 5 acre drainageways and 5 to 100 acre, nearly level landscapes. Where undrained, the perched water table ranges from 1 to 3 feet. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is 2.0 to 6.3 inches per hour in the upper loamy layers and greater than 6.3 inches per hour in the sandy underlying material. Hydrologic group C, undrained; B, drained.

Lemond are poorly drained, calcareous, loamy over coarse textured, grassland soils. They formed in 18 to 34 inches of sandy loam or loam sediments over sand. They occupy 3 to 5 acre drainageways and 5 to 100 acre, nearly level landscapes. Where undrained, the perched water table ranges from 1 to 3 feet. Where drained, the

rooting zone is near tile depth. Estimated saturated permeability is 2.0 to 6.3 inches per hour in the upper loamy layers and greater than 6.3 inches per hour in the sandy underlying material. Hydrologic group C, undrained; B, drained.

Litchfield are somewhat poorly to moderately well drained, medium acid to neutral, sandy, grassland soils. They formed in loamy fine sand upper layers over fine and medium sandy underlying material that in places is stratified with loamy material. They occupy 3 to 40 acre, level to gently sloping landscapes. The perched water table is at 3 to 5 feet during wet periods. The rooting zone is unrestricted except for the water table. Estimated saturated permeability is 2.0 to 6.3 inches per hour in the upper loamy sand mantle and greater than 6.3 inches per hour in the sandy underlying material. Hydrologic group A.

Mayer are poorly drained, calcarious, loamy over coarse textured grassland soils. They formed in 24 to 36 inches of loam over sand and gravel. They occupy 2 to 100 acre, nearly level broad flats and narrow draws. Where undrained, the perched water table ranges seasonally at 1 to 3 feet. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is 0.6 to 2.0 inches per hour in the loamy upper layers and greater than 6.3 inches per hour in the sandy and gravelly underlying material. Hydrologic group D, undrained; B, drained.

Rosendale are somewhat poorly to moderately well drained, slightly acid to mildly alkaline, loamy grassland soils. They formed in 20 to 40 inches of loams over stratified sands and loams. The sand fraction is dominantly fine and very fine. They occupy 3 to 40 acre flats and gentle rises. The rooting zone is unrestricted in the upper 60 inches. Estimated saturated permeability is 2.0 to 6.3 inches per hour in the upper loamy mantle and variable in the stratified underlying material but is estimated to range from 2.0 to greater than 6.3 inches per hour. Hydrologic group B.

Salida are excessively drained, calcarious, sandy and gravelly grassland soils, They formed in thick gravelly sediments. They occupy 3 to 40 acre convex, gravelly knolls and side slopes. The rooting zone is restricted by the high lime content and the gravelly texture. Estimated saturated permeability is greater than 6.3 inches per hour. Hydrologic group A.

Sparta are excessively drained, slightly to medium acid, sandy, grassland soils. They formed in more than 4 feet of loamy sand and sandy outwash and kame deposits. They occupy 3 to 15 acre knolls. The rooting zone is unrestricted. Estimated saturated permeability is greater than 6.3 inches per hour. Hydrologic group A.

Wadena are well drained, medium to slightly acid, loamy over coarse textured, grassland soils. They formed in 24 to 40 inches of loamy sediments over sands and gravel. They occupy 3 to 80 acres of nearly level to sloping landscapes. The rooting zone is slightly restricted in the gravelly underlying material. Estimated saturated permeability in the loamy upper layers ranges from .63 to 2.0 inches per hour and greater than 6.3 inches per hour in the gravelly underlying material. Hydrologic group B.

Soil number 17 are moderately well drained, neutral, sandy floodplain soils. They formed in 30 to 50 inches of sandy loam and loamy sand over sand. They occupy floodplain positions, and are ocassionally to frequently flooded. The rooting zone is unrestricted in the upper 60 inches. Estimated saturated permeability is 2.0 to 6.3 inches per hour. Hydrologic group C.

Soil number 25 are moderately well drained, neutral, loamy floodplain soils. They formed in over 40 inches of loam alluvial sediments. They occupy abandoned floodplain positions. The perched water table is seasonally from 3 to 5 feet and is commonly controlled by stream water level. They are occasionally flooded. The rooting

zone is unrestricted to the water table. Estimated saturated permeability is 2.0 to 6.3 inches per hour. Hydrologic group C.

Soil number 95 are moderately well drained, neutral to slightly acid, loamy floodplain soils. They formed in over 40 inches of loam alluvial sediments. They occupy abandoned floodplain positions, and are commonly above flood levels. The perched water table is seasonally from 3 to 5 feet. The rooting zone is unrestricted to the water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

IV. Blue Earth River Subbasin - Area 4

A. Physiography

1. Gently Rolling to Rolling Silt Mantled Ground Moraine

This area represents about 11 percent of the Blue Earth River Subbasin. The dominant landform is a complex of low knolls that rise irregularly above a lower level. Slope irregularity has been subdued by a silt mantle. The lower level begins as a weakly defined drainage net amongst the knolls and decends in a winding pattern to a broader nearly level plain interspersed with closed depressions and gentle rises.

The knolls seemingly are irregularly emplaced on a regional slope. The dominant relief is 5 to 20 feet above the knoll base. Slopes are short, 60 to 200 feet, and are convex in the upper segment and concave in the lower segment. Summits are narrow and are commonly segments of the upper convex of adjoining slopes. Erosional energies are greatest on the middle and upper slope segments. Sediments accumulate on the lower concave slopes. Contour lines have a very erratic pattern.

The lower level commonly has ample engineering gradient for drainage development. Recency of deposition, climate and the base level of the major streams have limited the opportunities for the development of first and second order streams. This

landscape development has been preempted by a few drainage ditches and miles of drain tile. Depressions are common and generally closed. Water leaves the depressions through drain tile. Some depressions have a peat cover that overlies limnic or terric sediments.

The surficial material is dominantly a silty mantle 2 to 20 feet thick, presumably lacustrine, either in place or collapsed. Sandy kames are numerous in some locations and lacking in others.

Sediment yields are estimated to be less than 15 tons per square mile per year.

B. Soils

The dominant soils are Collinwood, Kingston, Lura, Madelia, Spicer and Waldorf. Minor soils are Barbert, Grogan, Dickinson and Peat and Muck.

A typical section has about 40 percent poorly drained soils with extremes ranging from 30 to 50 percent.

Collinwood are moderately well to somewhat poorly drained, neutral to medium acid, silty clay or heavy silty clay loam grassland soils. They formed in a $3\frac{1}{2}$ to 8 foot thick lacustrine mantle over loamy glacial till. They occupy 2 to 15 acre low convex slopes. A perched water table is at 3 to 5 feet for short periods and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet except for a perched water table. Estimated saturated permeability is .20 to .63 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Kingston are moderately well to somewhat poorly drained, neutral to slightly acid silty clay loam and silt loam grassland soils. They formed in $3\frac{1}{2}$ to 15 feet thick lacustrine sediments over loamy glacial till. They occupy 2 to 15 acre low convex slopes. A perched

water table is at 3 to 5 feet for short periods and in places is near 1½ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet except for a perched water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Lura are very poorly drained, neutral to slightly acid silty clay or heavy silty clay loam grassland soils. They formed in 3 to 6 feet of lacustrine sediments over loamy glacial till. They occupy 1 to 5 acre depressions and 5 to 40 acre long, winding, low gradient drainageways. Where drained, a perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .06 to .63 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Madelia are poorly drained, neutral to slightly acid silty clay loam and silt loam grassland soils. They formed in 3½ to 6 feet of lacustrine sediments over loamy glacial till. They occupy 10 to 200 acre or more broad nearly level slopes and 3 to 10 acre narrow drainageways. In places they are in complex with Spicer soils. Where undrained, the rooting zone is commonly near tile depth. Estimated saturated permeability of .63 to 2.0 inches per hour. Hydrologic group C, undrained; B, drained.

Spicer are poorly drained, calcareous silty clay loam and silt loam grassland soils. They formed in 3½ to 6 feet of lacustrine sediments over loamy glacial till. They occupy 2 to 10 acre rims of depressions, depressions and slight rises and broad flats over 150 acres. Where undrained, a perched water table is at 1 to 1½ feet during parts of the growing season. Where drained, the rooting zone is commonly 3 to 4 feet deep. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C, undrained, B, drained.

Waldrof are poorly drained, neutral to mildly alkaline silty clay

grassland soils. They formed in $3\frac{1}{2}$ to 8 feet of lacustrine sediments over loamy glacial till. They occupy 10 to 200 acre or more broad level slopes. Where undrained, a perched water table is at 1 to $1\frac{1}{2}$ feet for short periods. Where drained, the rooting zone is commonly 3 to 4 feet deep. Estimated saturated permeability is .63 to 2.0 inches per hour in the least permeable zone. Hydrologic group B, undrained; C, drained.

Barbert are very poorly drained, medium to strongly acid silty clay grassland and woodland soils. They formed in $3\frac{1}{2}$ to 8 feet of lacustrine sediments over loamy glacial till. They occupy $\frac{1}{4}$ to 20 acre shallow depressions and drainageways. Where undrained, a water table is at or near the surface. Special tile spacing and open inlets are commonly needed for satisfactory water table control. Where drained, the rooting zone is near tile depth but is affected by the dense, acid subsoil. Estimated saturated permeability is .20 to .63 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Grogan are well drained, neutral or slightly acid loamy grassland soils. They formed in deltaic sediments high in fine and very fine sand that are $3\frac{1}{2}$ to 15 feet thick over loamy till, outwash sands or lacustrine sediments. They occupy 2 to 20 acre knolls. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is 2.0 to 6.3+ inches per hour in the upper horizons, in the lower horizons is variable from 2.0 to 6.3+ inches per hour. Hydrologic group B.

Dickinson are somewhat excessively drained, slightly to medium acid sandy grassland soils. They formed in a 20 to 30 inches mantle of sandy loam over sand. In places, they are associated with Clarion, Grogan, Kingston or Nicollet soils. They occupy 3 to 20 acre flats or low knolls. Except for low available water, the rooting zone is unrestricted in the upper 4 feet. Estimated

saturated permeability if 2.0 to 6.3 inches per hour in the upper horizons; 6.3+ inches per hour in the lower horizons. Hydrologic group A.

Peat and Muck are very poorly drained, slightly acid to calcareous soils. They formed in 18 to 60 inches of reed-sedge accumulations. They occupy 1 to 5 acre depressions to several hundred acre dead lakes. The underlying material is a buried soil in some places and 2 to 15 feet of lake sediments in others. Where undrained, a water table is at or near the surface. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is 5 to 8 inches per hour. Hydrologic group B, C or D.

V. Blue Earth River Subbasin - Area 5

A. Physiography

1. Clayey Mantled Ground Moraine and Ice Disintegration Features - This area represents about 18 percent of the Blue Earth River Subbasin. The dominant landform is one of nearly level to very gently undulating ground moraine further subdued by 2 to 6 feet mantle of clayey sediments. The sand fraction is dominated by shale. Highs are dominantly 3 to 10 feet above the lows. Depressions are small in size. Peat has filled some depressions. The peat overlies either limnic or terric sediments. This landform seemingly formed under glacial lake water or lake washed till plain or was down-wasted from the ice as a clayey slurry. The drainage net is low gradient and poorly integrated. It is crossed by a few streams. The streams are confined by entrenchments developed during the wasting of glacial ice. Few first, second or third order streams have developed in this immature landscape. Artifical drainage through tile provides most outlets. Most depressions are closed at the surface and drain underground to tile. Drainage ditches commonly outlet to entrenched intermittent streams or ravines. Outwash and valley train features are few and are non-existent over wide areas.

Sediment yields are estimated to be less than 10 tons per square mile per year. Ravine erosion is probably the greatest contributor.

B. Soils

The dominant soils are Cordova, Guckeen, Kamrar, Lerdal, Lura, Marna, Minnetonka, Shorewood and Peak and Muck. Minor soils are Barbert, Beauford, Collinwood, Grays, Lester, LeSueur and Shields.

A typical section is about 60 percent poorly drained soils with extremes from 50 to 70 percent.

Cordova are poorly drained, neutral to medium acid, heavy clay loam or silty clay loam woodland soils. In places they have small tracts of calcareous soils and shallow depressions with grayish acid soils. They formed in 2 to 4 feet of slightly modified clay loam till over loamy glacial till. Soil properties have been additionally modified by timber vegetation. Where undrained, a perched water table is at 1 to 3 feet. Where drained, the rooting zone is near tile depth and is slightly affected by a clayey acid subsoil. Estimated saturated permeability is .20 to .63 inches per hour in the least permeable zone. Hydrologic group C, undrained; B, drained.

Guckeen are moderately well and somewhat poorly drained, medium to slightly acid, clayey grassland soils. They formed in a mantle 3 to 6 feet thick of modified till over loamy till. They occupy 2 to 15 acre low convex slopes. A perched water table is at 3 to 5 feet during some seasons and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is unrestricted except for the perched water table. Estimated saturated permeability of .06 to .20 inches per hour in the least permeable zone. Hydrologic group C.

Kamrar are well to moderately well drained, medium to slightly acid, clayey grassland soils. They formed in a mantle of modified till 3 to 4 feet thick over a loamy till. They occupy 2 to 15 acre

moderately sloping rises and side slopes. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group B.

Lerdal are somewhat poorly to moderately well drained, medium to very strongly acid, clayey woodland soils. They formed in a modified glacial till high in content of shale. This clayey mantle ranges from 2½ to 6 feet over loamy till. They occupy 3 to 20 acre convex hill crests and steep, smooth side slopes. A perched water table is common at 2 to 3 feet during the spring or during periods of extended precipitation. This water table persists on all slopes. The rooting zone is affected by the acid, clayey subsoil and the perched water table. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group C.

Lura are very poorly drained, neutral to slightly acid, silty clay or heavy silt clay loam grassland soils. They formed in 3 to 6 feet of lacustrine sediments over loamy glacial till. They occupy 1 to 5 acre depressions and 5 to 40 acre long, winding, low gradient drainageways. Where undrained, a perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Marna are poorly drained, neutral to slightly acid, clayey grassland soils. They formed in 2½ to 4 foot mantle of modified clay loam or silty clay loam till over loamy till. They occupy 10 to 200 acres or more of broad, nearly level slopes. In places they have small areas of calcareous soils and shallow depressions with a grayish acid soil. Where undrained, a perched water table is at 1 to 3 feet. Where drained, the rooting zone is near tile depth. Estimated saturated

permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Minnetonka are poorly drained, slightly to medium acid, clayey woodland soils. They formed in a $2\frac{1}{2}$ to 4 foot mantle of lacustrine sediment over loamy till. They occupy 2 to 40 acre, nearly level slopes above the major stream entrenchments. In places they have shallow depressions with a grayish acid soil. Where undrained, a perched water table is at 1 to 3 feet. Where drained, the rooting zone is near tile depth but rooting zone is affected by the dense acid subsoil. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Shorewood are moderately well drained, medium to strongly acid, clayey woodland soils. They formed in $2\frac{1}{2}$ to 5 feet thick clayey sediments high in content of finely divided shale. They occupy 3 to 20 acre convex hill crests and steep smooth side slopes. A perched water table is at 3 to 5 feet for short periods. The rooting zone is unrestricted in the upper 4 feet but is affected by the dense acid subsoil. Estimated saturated permeability is .20 to .63 inches per hour in the least permeable zone. Hydrologic group C.

Peat and Muck are very poorly drained, slightly acid to calcareous soils. They formed in 18 to 60 inches of reed-sedge vegetative accumulations. They occupy 1 to 5 acre depressions to several hundred acre dead lakes. The underlying material is buried soil in some places and 2 to 15 feet of lake sediments in others. Where undrained, a water table is at or near the surface. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is 5 to 8 inches per hour. Hydrologic groups B, C, or D.

Barbert are very poorly drained, medium to strongly acid, clayey grassland soils. They formed in 3 to 6 feet of lacustrine or modified till sediments over loamy glacial till. They occupy 1 to

5 acre long, winding, low gradient drainageways. The perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is near tile depth. Tile function is improved by close lateral spacing and open inlets. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Beauford are poorly drained, clayey grassland soils. They formed in $3\frac{1}{2}$ to 8 foot thick lacustrine sediments. They occupy broad, level slopes of 40 to 200 acres or more. Shallow, grayish, acid depressions are common features in some places. The perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Collinwood are moderately well to somewhat poorly drained, neutral to medium acid, silty or heavy silty clay loam grassland soils. They formed in a $3\frac{1}{2}$ to 8 foot thick lacustrine mantle over loamy glacial till. They occupy 2 to 15 acre low convex slopes. A perched water table is at 3 to 5 feet for short periods and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet except for a perched water table. Estimated saturated permeability is .20 to .63 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Grays are well drained, strongly to medium acid, silty woodland soils. They formed in $3\frac{1}{2}$ to 5 feet of lacustrine sediments over loamy glacial till. They occupy 3 to 15 acre nearly level to strongly sloping relief. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Lester are well drained, strongly to slightly acid, loamy woodland soils. They formed in loamy glacial till. They occupy 3 to 20 acre gently sloping hill tops and side slopes. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

LeSueur are moderately well to somewhat poorly drained, strongly to slightly acid, loamy woodland soils. They formed in loamy glacial till. They occupy 3 to 40 acre nearly level hill tops and gentle rises. A perched water table is at 3 to 5 feet for short periods and in places is near 1½ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet except for a perched water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Shields are somewhat poorly to poorly drained, strongly to medium acid, woodland soils. They formed in a shaley, clayey mantle 3 to 6 feet thick over loamy glacial till. They occupy 3 to 100 acre nearly level to low convex slopes. Seasonally the perched water table is at 2 to 3 feet but is near 1 foot during periods of prolonged rainfall. The rooting zone is restricted by the clayey acid subsoil. Estimated saturated permeability is .20 to .63 inches per hour in the least permeable zone. Hydrologic group C.

IV. Blue Earth River Subbasin - Area 6 -

A. Physiography

1. Broad summit Clayey Mantled Morained and Ice Disintegration Features

This area represents about 3 percent of the Blue Earth River Subbasin. The dominant landform is one of circular, level topped hills bounded by smooth side slopes and above a broad lower level. An associated minor landform lack the broad summits. A few areas have irregular relief. These minor landforms are typically on lower relief.

The broad upper levels have nearly concurrent elevations. In places, the unobstructed view gives the impression of a level

plain. Summit widths vary regionally. Some group near 300 to 500 foot widths, some 1000 to 4000 feet, and few range to 4 miles. The summit rises from 20 to 30 feet above the lower level where the clayey mantle is thin to near 50 feet where clayey sediments are thick.

Slopes on the upper level are short, 60 to 100 feet and range from 0 to 6 percent, but are dominantly 2 to 3 percent. They express a subdued irregularity, but some are low convex. The watershed area of the upper level commonly outlets to one or two weakly incised waterways. The drainage net is poorly intergrated and commonly slopes away from the side slope shoulder to several low points. Depressions are small in size. Some have a peat cover. The peat overlies either limnic or terric sediments.

Side slopes are smooth with convex shoulders and concave backslopes. Contour lines are reasonably parallel.

The lower level has a poorly integrated drainage net with very low gradients. It is interspersed with closed depressions and lakes, some of which are intermittent, and peat bogs. In some places drainage gradients are controlled by lake levels.

This landform seemingly formed in or under a down-wasting stagnant ice field. The somewhat circular form and similar elevations were either resident in the basal till or was irregular relief subdued by drift fillings from the ice surface. The side slopes were the ice contact and the lowest level the ice floor.

Outwash and valley train features are very few and non-existent over wide areas. Smaller stream courses are without terraces or coarse textured sediments. Some side slopes have small kame deposits.

Recency of deposition, climate and base level of the major streams have limited the opportunity for development of first and second order streams. Artificial drainage ditches and tile drainage have been affective substitutes in places, but in many areas of the lower level have had limited drainage development.

Erosional energies are expressed mostly on the upper convex slope segment. Accumulations begin on the lower back slope and foot slope. Erosional sediments are not usually discernible on either the depressional wet soils or peat soils. Most depressions remain closed to surface drainage and are drained underground by tile.

Sediment yields are estimated to be less than 100 tons per square mile per year. (This may be too high).

B. Soils

The dominant soils are Cordova, Glencoe, Kilkenny, Ledal and Peat and Muck. Minor soils are Canisteo, Dundas, Lester, LeSueur and Shields.

A typical section is about 45 percent poorly drained with extremes from 35 to 55 percent.

Cordova are poorly drained, neutral to medium acid, heavy clay loam or silty clay loam woodland soils. In places they have small tracts of calcareous soils and shallow depressions with grayish acid soils. They formed in 2 to 4 feet of slightly modified clay loam till over loamy glacial till. Soil properties have been additionally modified by timber vegetation. When undrained, a perched water table is at 1 to 3 feet. Where drained, the rooting zone is near tile depth and is slightly affected by a clayey acid subsoil. Estimated saturated permeability is .20 to .63 inches per hour in the least permeable zone. Hydrologic group C, undrained; B, drained.

Glencoe are very poorly drained, neutral to mildly alkaline, loamy grassland soils. They formed in glacial pediment 3 to 6 feet thick over glacial till. They occupy 1 to 5 acre depresseions and 5 to 40 acre long, winding, low gradient drainageways. Where undrained a perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group D, undrained; C, drained.

Kilkenny are well drained, strongly to medium acid, clayey woodland soils. They formed in a 30 to 60 inches of clayey mantle over loam till. The mantle is commonly high in content of shale. They occupy 3 to 20 acre convex, hill crests to steep smooth side slopes. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .20 to .63 inches per hour. Hydrologic group B.

Ledal are somewhat poorly to moderately well drained, medium to very strongly acid, clayey woodland soils. They formed in modified glacial till high in content of shale. This clayey mantle ranges from 2½ to 6 feet over loamy till. They occupy 3 to 20 acre convex hill crests and steep, smooth side slopes. A perched water table is common at 2 to 3 feet during the spring or during periods of extended precipitation. This water table persists on all slopes The rooting zone is affected by the acid, clayey subsoil and the perched water table. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group C.

Peat and Muck are very poorly drained, slightly acid to calcareous soils. They formed in 18 to 60 inches of reed-sedge vegetative accumulations. They occupy 1 to 5 acre depressions to several hundred acre dead lakes. The underlying material is a buried soil in some places and 2 to 15 feet of lake sediments in others. Where

undrained, a water table is at or near the surface. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is 5 to 8 inches per hour. Hydrologic groups B, C or D.

Canisteo are poorly and very poorly drained, loamy, calcareous grassland soils. They formed in glacial till. They occupy 2 to 10 acre rims of depressions and slight rises and broad flats to 150 acres. Where undrained, the perched water table is at 1 to $1\frac{1}{2}$ feet during parts of the growing season. Where drained, the rooting zone is commonly 3 to 4 feet deep. Estimated saturated permeability is .63 to 2.0 inches per hour Hydrologic group C, undrained; B, drained.

Dundas are somewhat poorly to poorly drained, strongly to medium acid, woodland soils. They formed in glacial till or slightly modified glacial till. They occupy 3 to 15 acre, nearly level and very low convex slopes and 3 to 8 acre shallow drainageways. Seasonally the water table is within 2 to 3 feet of the surface and during periods of prolonged rainfall is near 1 foot. The rooting zone is affected by the perched water table and acid subsoil. Estimated saturated permeability is .20 to .63 inches per hour in the least permeable zone. Hydrologic group C.

Lester are well drained, strongly to slightly acid, loamy woodland soils. They formed in loamy glacial till. They occupy 3 to 20 acre gently sloping hill tops and side slopes. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

LeSueur are moderately well to somewhat poorly drained, strongly to slightly acid, loamy woodland soils. They formed in loamy glacial till. They occupy 3 to 40 acre nearly level hill tops and gentle rises. A perched water table is at 3 to 5 feet for short periods and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall.

The rooting zone is unrestricted in the upper 4 feet except for a perched water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Shields are somewhat poorly to poorly drained, strongly to medium acid, woodland soils. They formed in a shaley, clayey mantle 3 to 6 feet thick over loamy glacial till. They occupy 3 to 100 acre nearly level to low convex slopes. Seasonally the perched water table is at 2 to 3 feet but is near 1 foot during periods of prolonged rainfall. The rooting zone is restricted by the clayey acid subsoil. Estimated saturated permeability is .20 to .63 inches per hour in the least permeable zone. Hydrologic Group C.

VII. Blue Earth River Subbasin - Area 7

A. Physiography

1. Undulating Ground Moraine

This area represents about 9 percent of the Blue Earth River Subbasin. The dominant landform is one of a nearly level to gently undulating ground moraine. The few highs are typically 5 to 15 feet above the lows. Where they adjoin broad summit landscapes and irregular landscapes, they express subdued features of these associates. They are also associated, at a slightly higher regional elevation, with level clayey mantled till plains. Evidence of post glacial sediment is common in the lower elevations. Depressions are small in size. Peat has formed in some depressions and overlies either limnic or terric sediments. This landform formed in or under a down-wasting stagnant ice field of loamy glacial drift. The drainage net is low gradient and poorly integrated. Few first, second and third order streams developed in this immature landscape. Artificial drainage provides most outlets. Many depressions are closed at the surface and drain underground to tile. Drainage ditches commonly outlet to intermittent streams. These streams occupy glacial melt water entrenchments or are ravines adjacent to the

major streams. Outwash and valley train features are few and are nonexistent over wide areas.

Sediment yields estimated to be less than 10 tons per square mile per year. Ravine erosion is probably the greatest contributor.

B. Soils

The principal soils are Canisteo, Glencoe, Nicollet, Webster and Peat and Muck. Minor soils are Clarion, Marna and Storden.

A typical section is about 60 percent poorly drained soils with extremes from 50 to 70 percent.

Canisteo are poorly and very poorly drained, loamy, calcareous grassland soils. They formed in glacial till. They occupy 2 to 10 acre rims of depressions and slight rises and broad flats to 150 acres. Where undrained, the perched water table is at 1 to $1\frac{1}{2}$ feet during parts of the growing season. Where drained, the rooting zone is commonly 3 to 4 feet deep. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C, undrained; B, drained.

Glencoe are very poorly drained, neutral to mildly alkaline, loamy grassland soils. They formed in glacial pediment 3 to 6 feet thick over glacial till. They occupy 1 to 5 acre depressions and 5 to 40 acre long, winding, low gradient drainageways. Where drained, a perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group D, undrained; C, drained.

Nicollet are moderately well to somewhat poorly drained, slightly or medium acid, loamy grassland soils. They formed in glacial till, they occupy 2 to 15 acre low knolls. A perched water table

is at 3 to 5 feet for short periods and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet except for perched water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Webster are poorly drained, neutral to slightly acid, loamy grassland soils formed in glacial till and are commonly in complex with Canisteo and Harps soils. They occupy 10 to 200 acre or more broad, nearly level slopes and 3 to 10 acre narrow drainageways. Where undrained, the perched water table is at 1 to 3 feet. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C, undrained; B, drained.

Peat and Muck are very poorly drained, slightly acid to calcaréous soils. They formed in 18 to 60 inches of reed-sedge vegetative accumulations. They occupy 1 to 5 acre depressions to several hundred acre dead lakes. The underlying material is a buried soil in some places and 2 to 15 feet of lake sediment in others. Where undrained, a water table is at or near the surface. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is 5 to 8 inches per hour. Hydrologic group B, C or D.

Clarion are well drained, slightly or medium acid, loamy grassland soils. They formed in glacial till. They occupy 3 to 20 acre irregular knolls and ridge crests. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Marna are poorly drained, neutral to slightly acid, clayey grassland soils. They formed in $2\frac{1}{2}$ to 4 foot mantle of modified clay loam or silty clay loam till over loamy till. They occupy 10 to 200 acres or more or broad nearly level slopes. In places they have small areas of calcareous soil and shallow depressions with a grayish acid soil. Where undrained, a perched water table

is at 1 to 3 feet. Where drained, the rooting zone is near tile depth. Estimated saturated permeability of .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Storden are well drained, calcareous loamy grassland soils. They formed in glacial till. They occupy $\frac{1}{2}$ to 1 acre convex slopes in complex with the Clarion soils. The rooting zone is restricted by the high concentrations of lime carbonates affecting plant nutrition or by limiting rooting zone moisture due to slope form. Estimated saturated permeability is .63 to 2.0 inches per hour (could be lower due to weak structure or high concentrations of fine lime carbonates). Hydrologic group B.

VIII. Blue Earth River Subbasin - Area 8

A. Physiography

1. Broad Summit Loamy Mantled Morained and Ice Disintegration Features

This area represents about 10 percent of the Blue Earth River Subbasin. The dominant landform is one of circular, level topped hills bounded by smooth side slopes and above a broad lower level. An associated minor landform lacks the broad summits. A few areas have irregular relief. These minor landforms are typically at the lower levels. The broad upper levels have nearly concurrent elevations. In places, the unobstructed view gives the impression of a level plain. Summit widths vary regionally. Some group near 200 to 500 feet, some near 1000 to 4000 feet, and few range to 2 miles. The summits rise from 10 to 30 feet above the lower level. Slopes on the upper level are short, ranging from 0 to 6 percent, but are dominantly 2 to 3 percent. They express a subdued irregularity. Side slopes range from 4 to 35 percent, but are dominantly 8 to 14 percent.

The watershed area of the upper level commonly outlets to one or two weakly incised waterways. The drainage net is poorly integrated and commonly slopes away from the side slope shoulder to several low points. Depressions are small in size.

Side slopes are smooth with convex shoulders and concave back slopes. Contour lines are reasonably parallel.

The lower level has a poorly integrated drainage net with a very low gradient. It is interspersed with closed depressions and lakes, some of which are intermittent, and peat bogs. In places, gradients are controlled by lake levels. Gradients typically are higher than areas that are clayey mantled.

This landform seeimingly formed in or under a down-wasting stagnant ice field, with clayey sediment high in content of shale. The somewhat circular form and similar elevation were either resident in the basal till or irregular relief was subdued by drift fillings from the ice surface. The side slopes were ice contact and the lower level was the ice floor.

B. Soils

The dominant soils in the northeast section of the area are Canisteo, Cordova, Lester, LeSueur and Peat and Muck. Minor soils are Dundas, Kilkenny, Storden and Webster. The dominant soils in the southwestern section are Canisteo, Clarion, Glencoe, Nicollet, Webster and Peak and Muck. Minor soils are Storden and Terril.

A typical section is about 45 percent poorly drained soils with extremes from 35 to 55 percent.

1. Northeast Section

Canisteo are poorly and very poorly drained, loamy calcareous grassland soils. They formed in glacial till. They occupy 2 to 10 acre rims of depressions and slight rises and broad flats to 150 acres. Where undrained, the perched water table is at

1 to $1\frac{1}{2}$ feet during parts of the growing season. Where drained, the rooting zone is commonly 3 to 4 feet deep. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C, undrained; B, drained.

Cordova are poorly drained, neutral to medium acid, heavy clay loam or silty clay loam woodland soils. In places they have small tracts of calcareous soils and shallow depressions with grayish acid soils. They formed in 2 to 4 feet of slightly modified clay loam till over loamy glacial till. Soil properties have been additionally modified by timber vegetation. Where undrained, a perched water table is at 1 to 3 feet. Where drained the rooting zone is near tile depth and is slightly effected by a clayey acid subsoil. Estimated saturated permeability is .20 to .63 inches per hour in the least permeable zone. Hydrologic group C, undrained; B, drained,

Lester are well drained, strongly to slightly acid, loamy woodland soils. They formed in loamy glacial till. They occupy 3 to 20 acre gently sloping hill tops and side slopes. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

LeSueur are moderately well to somewhat poorly drained, strongly to slightly acid, loamy woodland soils. They formed in loamy glacial till. They occupy 3 to 40 acre nearly level hill tops and gentle rises. A perched water table is at 3 to 5 feet for short periods and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet except for a perched water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Peat and Muck are very poorly drained, slightly acid to calcareous soils. They formed in 18 to 60 inches of reed-sedge vegetative accumulations. They occupy 1 to 5 acre depressions to several

hundred acre dead lakes. The underlying material is a buried soil in some places and 2 to 15 feet of lake sediments in others. Where undrained, a water table is at or near the surface. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is 5 to 8 inches per hour. Hydrologic group B, C, or D.

2. Southwest Section

Canisteo are poorly and very poorly drained, loamy calcareous grassland soils. They formed in glacial till. They occupy 2 to 10 acre rims of depressions and slight rises and broad flats to 150 acres. Where undrained, the perched water table is at 1 to 1½ feet during parts of the growing season, Where drained, the rooting zone is commonly 3 to 4 feet deep. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C, undrained; B, drained.

Clarion are well drained, slightly or medium acid, loamy grassland soils. They formed in glacial till. They occupy 3 to 20 acre irregular knolls and ridge crests. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Glencoe are very poorly drained, neutral to mildly alkaline, loamy grassland soils. They formed in glacial pediment 3 to 6 feet thick over glacial till. They occupy 1 to 5 acre depressions and 5 to 40 acre long, winding, low gradient drainageways. Where undrained, a perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group D, undrained; C, drained.

Nicollet are moderately well to somewhat poorly drained, slightly to medium acid, loamy grassland soils. They formed in glacial

till. They occupy 2 to 15 acre low knolls. A perched water table is at 3 to 5 feet for short periods and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet except for perched water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Webster are poorly drained, neutral to slightly acid, loamy grassland soils formed in glacial till and are commonly in complex with Canisteo and Harps soils. They occupy 10 to 200 acre or more broad nearly level slopes and 3 to 10 acre narrow drainageways. Where undrained, the perched water table is at 1 to 3 feet. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C, undrained; B, drained.

Peat and Muck are very poorly drained, slightly acid to calcareous soils. They formed in 18 to 60 inches of reed-sedge vegetative accumulations. They occupy 1 to 5 acre depressions to several hundred acre dead lakes. The underlying material is a buried soil in some places and 2 to 15 of lake sediments in others. Where undrained, a water table is at or near the surface. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is 5 to 8 inches per hour. Hydrologic group B, C, or D.

Storden soils are well drained, calcareous, loamy grassland soils formed in glacial till. They occupy $\frac{1}{2}$ to 5 acre convex slopes and ridge crests. The rooting zone is restricted by high concentrations of lime carbonates affecting plant nutrition or by limited rooting zone moisture due to slope form. Estimated saturated permeability is .63 to 2.0 inches per hour (could be lower due to weak structure and high concentration of fine lime carbonates). Hydrologic group B.

Terril are well and moderately well drained, slightly acid or neutral loamy soils. They formed in thick erosional pediment

along the lower concave slopes and occupy long, narrow strips at the base of the Clarion slopes. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

IX. Blue Earth River Subbasin - Area 9a, 9b,9c

A. Physiography

1. Irregular Loamy Ground, End and Terminal Moraines and Ice Disintegration Features

This area represents about 29 percent of the Blue Earth Subbasin. This area is comprised of 25.7 percent gently rolling relief, 3 percent rolling and .3 percent strongly rolling.

The dominant landform is a complex of knolls that rise irregularly above a lower level. The lower level begins as a weakly defined drainage net amongst the knolls and decends in a winding pattern to a broader nearly level plain interspersed with closed depressions and gentle rises and, in places, by isolated higher knolls.

The knolls seemingly are irregularly emplaced on an underlying slope. The underlying slope controls the drainage and the knolls ascend and descend with changes within this slope. The dominant relief is 5 to 15 feet above the knoll base in the gently rolling areas, 10 to 30 feet in the rolling areas, and 20 to 100 feet, in the strongly rolling areas. Position on regional slope is unrelated to knoll base to summit height. Slopes are short, 60 to 200 feet, and are convex in the upper segment and concave in the lower segment. Summits are narrow and commonly are segments of the upper convex of adjoining slopes. Erosional energies are greatest on the middle and upper slope segments. Sediments accumulate on the lower concave slopes. Contour lines have a erratic pattern.

The lower level commonly has ample engineering gradients for drainage development but there are locations, particularly in the strongly rolling areas where deeply inset depressions preclude economical artificial drainage. Recency of deposition, climate and base level of the major streams have limited the opportunity for the development of many first and second order streams. This landscape development has been preempted by a few drainage ditches and miles of drain tile. The depressions and dead lakes are filled with peat cover over limnic or terric sediments. Few recent erosional sediments are discernible in these depressions.

The surficial material is dominantly a loamy calcareous till but modified drift in the form of silts and clay occurs in small amounts in scattered areas.

This landform seemingly emerged along an active ice edge with extrusion flows to the ice surface with subsequent slumping from the irregularly melting ice.

Outwash valley trains, kames and eskers are common associated features.

Sediment yields on gently rolling areas are estimated to be less than 15 tons per square mile per year, rolling less than 25 tons and strongly rolling less than 50 tons. However, the deeply inset depressions in the rolling and strongly rolling areas may prove these estimates to be high.

B. Soils

1. Area 9a

The dominant soils are Canisteo, Clarion, Glencoe, Nicollet, Webster and Peak and Muck, Minor soils are Storden and Terril.

A typical section has about 60 percent poorly drained soils with extremes ranging from 40 to 80 percent.

2. Area 9b

The dominant soils are Canisteo, Clarion, Glencoe, Nicollet, Webster and Peat and Muck. Minor soils are Estherville, Storden, Terril and Wadena.

A typical section has about 45 percent wet soils with extremes from 35 to 55 percent.

3. Area 9c

The dominant soils are Canisteo, Clarion, Glencoe, Nicollet, Webster and Peat and Muck. Minor soils are Estherville, Storden, Terril and Wadena.

A typical section has about 35 percent wet soils with extremes from 30 to 40 percent.

Canisteo are poorly and very poorly drained, calcareous loamy grassland soils. They formed in glacial till. They occupy 2 to 10 acre rims, depressions and slight rises and over 150 acres of broad flats. Where undrained, the perched water table is at 1 to $1\frac{1}{2}$ feet during part of the growing season. Where drained, the rooting zone is commonly 3 to 4 feet deep. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C, undrained; B drained.

Clarion are well drained, slightly or medium acid loamy grassland soils. They formed in glacial till. They occupy 3 to 20 acre irregular knolls. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Estherville are excessively drained, slightly or medium acid, sandy grassland soils. They formed in a sandy loam mantle over sands and gravel. They occupy 1 to 10 acre knolls and flats within areas of loamy soils. Effective rooting zone

is commonly less than 24 inches. Estimated saturated permeability is 2.0 to 6.3 in upper horizons and 6.3 in sand and gravel substratum. Hydrologic group B.

Glencoe are very poorly drained, slightly acid to mildly alkaline grassland soils. They formed in glacial pediment 3 to 6 feet thick over glacial till. They occupy 1 to 5 acre depressions and 5 to 40 acre long, winding, low gradient drainageways. Where undrained, a perched water table varies seasonally from near the surface to 3 feet deep. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group D, undrained; C, drained.

Nicollet are moderately well drained to somewhat poorly drained, slightly to medium acid, loamy grassland soils. They formed in glacial till. A perched water table is at 3 to 5 feet for short periods, but in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet except for perched water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Storden are well drained, calcareous, loamy grassland soils. They formed in glacial till. They occupy $\frac{1}{2}$ to 1 acre convex slopes in complex with the Clarion soils. The rooting zone is restricted by the high concentrations of lime carbonates affecting plant nutrition or by limiting rooting zone moisture due to slope form. Estimated saturated permeability is .63 to 2.0 inches per hour (could be lower due to weak structure or high concentrations of fine lime carbonates). Hydrologic group B.

Terril are well and moderately well drained, slightly acid or neutral, loamy grassland soils. They formed in thick erosional pediment along the lower concave slopes and occupy long, narrow strips at the base of the Clarion slopes. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability

is .63 to 2.0 inches per hour. Hydrologic group B.

Wadena are well drained, slightly or medium acid, loamy grassland soils. They formed in a loam or sandy loam mantle over sands and gravel. They occupy 1 to 10 acre knolls and flats within areas of loamy soils. Effective rooting zone is commonly less than 36 inches. Estimated saturated permeability if .63 to 2.0 inches per hour in the upper horizons and 6.3 in the sand and gravel substratum. Hydrologic group B.

Webster are poorly drained, neutral or slightly acid, loamy grassland soils. They formed in glacial till. They occupy 10 to 200 acre or more broad, nearly level slopes and 3 to 10 acre narrow drainageways. Where undrained, the perched water table is at 1 to 3 feet. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group C, undrained; B, drained.

Peat and Muck are very poorly drained, slightly acid to calcareous soils. They formed in reed-sedge vegetative accumulations from 18 to 60 inches thick. They occupy 1 to 5 acre depressions and 5 to several hundred acre dead lakes. The underlying material is a buried soil in some places and 2 to 15 feet of lake sediment in others. Where undrained, a water table is at or near the surface. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is 5 to 8 inches per hour. Hydrologic group B, C, or D.

X. Blue Earth River Subbasin - Area 10

A. Physiography

1. Clayey Glacial Lake Basin

This area represents about 6 percent of the Blue Earth River Subbasin. The dominant landform is a level to nearly level clayey mantled low relief ground moraine. The few highs are

dominantly 3 to 6 feet above the lows. Depressions are commonly small in size. Peat has filled some depressions. The peat overlies either limnic or terric sediments. This landform formed in deep, sediment filled glacial lake water. These conditions were favorable for the settling out of clayey sediments. They range from 4 to 10 feet thick. The drainage net is low gradient and poorly integrated. The area is crossed by few streams. The streams are confined by entrenchments developed during the wasting of glacial ice. Few first, second and third order streams developed in this immature landscape. Artificial drainage in the form of a few ditches and miles of tile provides most water outlets. Most depressions are closed at surface and drain underground to tile. Drainage ditches commonly outlet to entrenched intermittent streams or ravines. Outwash and valley train features are few and are non-existent over wide areas.

Sediment yields are estimated to be less than 10 tons per square mile per year. Ravine erosion is the greatest contributor.

B. Soils

The dominant soils are Beauford, Lura and Wells. Minor soils are Barbert, Collinwood, Guckeen, Kamrar, Marna and Waldorf.

A typical section is about 70 percent poorly drained soils with extremes from 60 to 80 percent.

Beauford are poorly drained, neutral to slightly acid, clayey grassland soils. They formed in $3\frac{1}{2}$ to 8 foot thick lacustrine sediments. They occupy broad, level slopes of 40 to 200 acres or more. Shallow, grayish, acid depressions are common features in some places. The perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Lura are very poorly drained, neutral to slightly acid, silty clay or heavy silty clay loam grassland soils. They formed in 3 to 6 feet of lacustrine sediments over loamy glacial till. They occupy 1 to 5 acre depressions and 5 to 40 acre long, winding, low gradient drainageways. Where undrained, a perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Wells are moderately well to somewhat poorly drained, slightly to strongly acid clayey grassland soils. They formed in a 3 to 6 foot thick mantle of clayey sediments over loamy till. They occupy 2 to 15 acre low convex slopes. A perched water table is at 3 to 5 feet during some seasons and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is modified by the high clay subsoils and at times by a perched water table. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group C.

Barbert are very poorly drained, medium to strongly acid, clayey grassland soils. They formed in 3 to 6 feet of lacustrine or modified till sediments over loamy glacial till. They occupy 1 to 5 acre long, winding, low gradient drainageways. The perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is near tile depth. Tile function is improved by close lateral spacing and open inlets. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Collinwood are moderately well to somewhat poorly drained, neutral to medium acid, silty or heavy silty clay loam grassland soils. They formed in a $3\frac{1}{2}$ to 8 foot thick lacustrine mantle over loamy glacial till. They occupy 2 to 15 acre low convex slopes. A

perched water table is at 3 to 5 feet for short periods and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet except for a perched water table. Estimated saturated permeability is .20 to .63 inches per hour in the least permeable zone. Hydrologic group D, undrained; C,drained.

Guckeen are moderately well and somewhat poorly drained, medium to slightly acid, clayey grassland soils. They formed in a mantle 3 to 6 feet thick of modified till over loamy till. They occupy 2 to 15 acre low convex slopes. A perched water table is at 3 to 5 feet during some seasons and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is unrestricted except for the perched water table. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group C.

Kamar are well to moderately well drained, medium to slightly acid, clayey grassland soils. They formed in a mantle of modified till 3 to 4 feet thick over a loamy till. They occupy 2 to 15 acre moderately sloping rises and side slopes. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group B.

Lerdal are somewhat poorly to moderately well drained, medium to very strongly acid, clayey woodland soils. They formed in a modified glacial till high in content of shale. The clayey mantle ranges from $2\frac{1}{2}$ to 6 feet over loamy till. They occupy 3 to 20 acre convex hill crests and steep, smooth side slopes. A perched water table is common at 2 to 3 feet during the spring or during periods of extended precipitation. This water table persists on all slopes. The rooting zone is affected by the acid,

clayey subsoil and the perched water table. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group C.

Marna are poorly drained, neutral to slightly acid, clayey grassland soils. They formed in 2½ to 4 foot mantle of modified clay loam or silty clay loam till over loamy till. They occupy 10 to 200 acre or more or broad, nearly level slopes. In places they have small areas of calcareous soils and shallow depressions with a grayish acid soil. Where drained, a perched water table is at 1 to 3 feet. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Waldorf are poorly drained, neutral to mildly alkaline, silty clay grassland soils. They formed in 3½ to 8 feet of lacustrine sediments over loamy glacial till. They occupy 10 to 200 acre or more broad level slopes. Where undrained, a perched water table is at 1 to 1½ feet for short periods. Where drained, the rooting zone is commonly 3 to 4 feet deep. Estimated saturated permeability is .63 to 2.0 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

XI. Blue Earth River Subbasin - Area 11

A. Physiography

1. Silty Glacial Lake Basin

This area represents about 4 percent of the Blue Earth River Subbasin. The dominant landform is one of a level to nearly level silty mantled low relief ground moraine. The few highs are dominantly 3 to 6 feet above the lows. Depressions are small in size. Peat has filled some depressions. The peat overlies either limnic or terric sediments. This landform

formed in deep, sediment filled glacial lake water. Conditions were favorable for settling out of silty sediments. They range from 4 to 10 feet thick. The drainage net is low gradient and poorly integrated. The area is crossed by a few streams. The streams are confined by entrenchments developed during the wasting of glacial ice. Few first and second order streams were developed in this immature landscape. Artificial drainage in the form of a few ditches and miles of tile provides most water outlets. Most depressions are closed at the surface and drain underground to tile. Drainage ditches commonly outlet to entrenched intermittent streams or ravines. Outwash and valley train features are few and are non-existent over wide areas.

Sediment yields are estimated to be less than 10 tons per square mile per year. Ravine erosion is the greatest contributor.

B. Soils

The dominant soils are Collinwood, Guckeen, Lura, Marna and Waldorf. Minor soils are Barbert, Clarion, Kamrar, Kingston and Madelia.

A typical section is about 60 percent poorly drained soils with extremes from 50 to 70 percent.

Collinwood are moderately well to somewhat poorly drained, neutral to medium acid, silty or heavy silty clay loam grassland soils. They formed in a 3½ to 8 foot thick lacustrine mantle over loamy glacail till. They occupy 2 to 15 acre low convex slopes. A perched water table is at 3 to 5 feet for short periods and in places is near 1½ feet during periods of prolonged rainfall. The rooting zone is unrestricted in the upper 4 feet except for the perched water table. Estimated saturated permeability is .20 to .63 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Guckeen are moderately well and somewhat poorly drained, medium to slightly acid, clayey grassland soils. They formed in a mantle 3 to 5 feet thick of modified till over loamy till. They occupy 2 to 15 acre low convex slopes. A perched water table is at 3 to 5 feet during some seasons and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The rooting zone is unrestricted except for the perched water table. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group C.

Lura are very poorly drained, neutral to slightly acid, silty clay or heavy silty clay loam grassland soils. They formed in 3 to 6 feet of lacustrine sediments over loamy glacial till. They occupy 1 to 5 acre depressions and 5 to 40 acre long, winding, low gradient drainageways. Where undrained, a perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Marna are poorly drained, neutral to slightly acid, clayey grassland soils. They formed in $2\frac{1}{2}$ to 5 foot mantle of modified clay loam of silty clay loam till over loamy till. They occupy 10 to 200 acre or more of broad, nearly level slopes. In places they have small areas of calcareous soils and shallow depressions with a grayish acid soil. Where undrained, a perched water table is at 1 to 3 feet. Where drained, the rooting zone is near tile depth. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Waldorf are poorly drained, neutral to mildly alkaline, silty clay grassland soils. They formed in $3\frac{1}{2}$ to 8 feet of lacustrine sediments over loamy glacial till. They occupy 10 to 200 acre or more of broad level slopes. Where undrained, a perched water

table is at 1 to $1\frac{1}{2}$ feet for short periods. Where drained, the rooting zone is commonly 3 to 4 feet deep. Estimated saturated permeability is .63 to 2.0 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

Barbert are very poorly drained, medium to strongly acid, clayey grassland soils. They formed in 3 to 6 feet of lacustrine or modified till sediments over loamy glacial till. They occupy 1 to 5 acre long, winding, low gradient drainageways. The perched water table varies seasonally from near the surface to 3 foot depth. Where drained, the rooting zone is near tile depth. Tile function is improved by close lateral spacing and open inlets. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group D, undrained; C, drained.

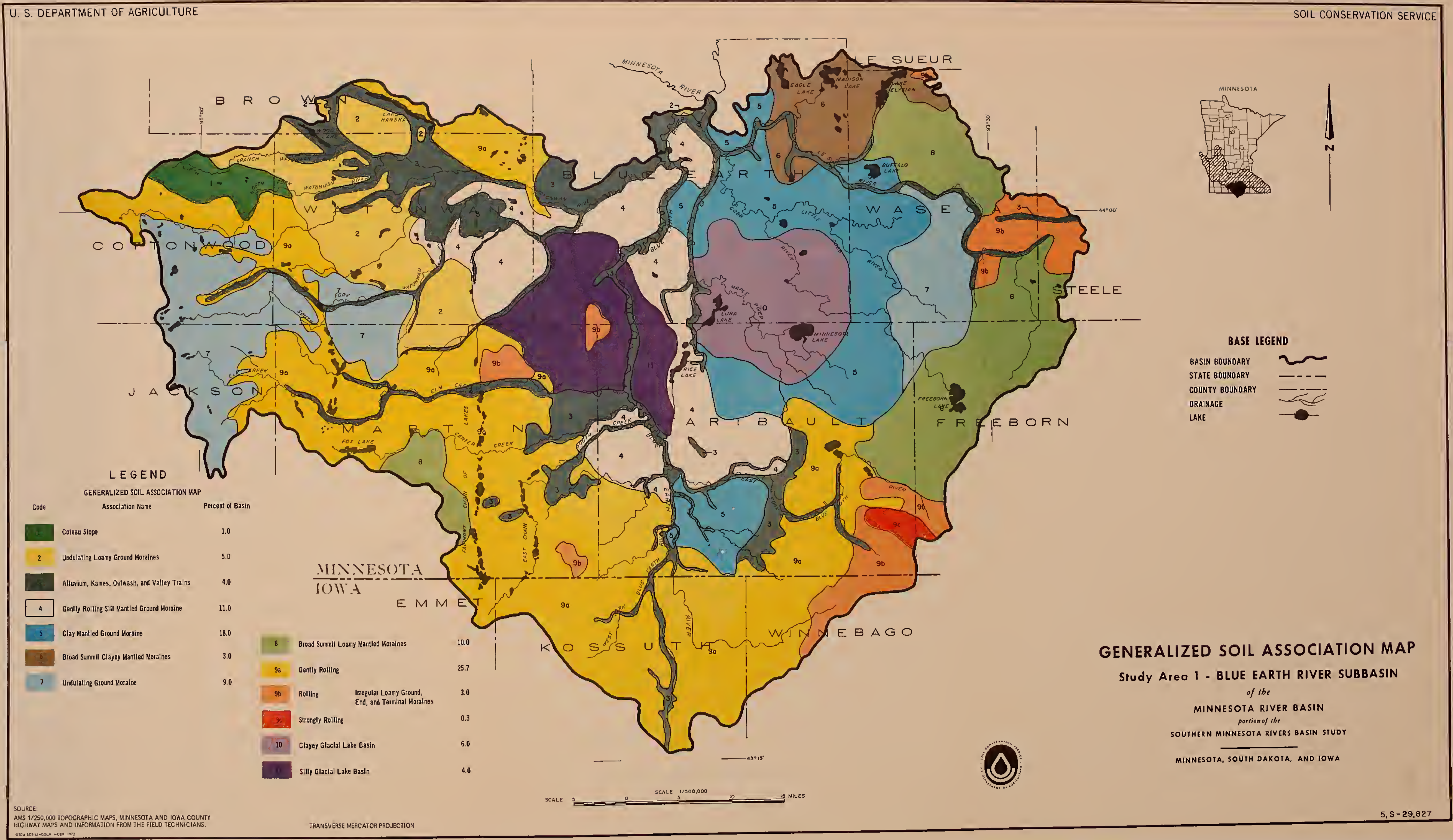
Clarion are well drained, slightly to medium acid, loamy soils formed in glacial till. They occupy 3 to 20 acre irregular knolls The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Kamrar are well to moderately well drained, medium to slightly acid, clayey grassland soils. They formed in a mantle of modified till 3 to 4 feet thick over a loamy till. They occupy 2 to 15 acre moderately sloping rises and side slopes. The rooting zone is unrestricted in the upper 4 feet. Estimated saturated permeability is .06 to .20 inches per hour in the least permeable zone. Hydrologic group B.

Kingston are moderately well to somewhat poorly drained, neutral to slightly acid silty clay loam and silt loam grassland soils. They formed in $3\frac{1}{2}$ to 15 feet thick lacustrine sediments over loamy glacial till. They occupy 2 to 15 acre low convex slopes. A perched water table is at 3 to 5 feet for short periods and in places is near $1\frac{1}{2}$ feet during periods of prolonged rainfall. The

rooting zone is unrestricted in the upper 4 feet except for a perched water table. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group B.

Madelia are poorly drained, neutral to slightly acid silty clay loam and silt loam grassland soils. They formed in $3\frac{1}{2}$ to 6 feet of lacustrine sediments over loamy glacial till. They occupy 10 to 200 acre or more broad nearly level slopes and 3 to 10 acre narrow drainageways. In places they are in complex with Spicer soils. Where undrained, the rooting zone is commonly near tile depth. Estimated saturated permeability is .63 to 2.0 inches per hour. Hydrologic group D, undrained; B, drained.



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
GENERALIZED SOIL ASSOCIATION MAP
Study Area 1 - BLUE EARTH RIVER SUBBASIN
of the
MINNESOTA RIVER BASIN
portion of the
SOUTHERN MINNESOTA RIVERS BASIN STUDY
MINNESOTA, SOUTH DAKOTA, AND IOWA
LEGEND
GENERALIZED SOIL ASSOCIATION MAP
Code | Association Name | Percent of Basin
1 Coteau Slope 1.0
2 Undulating Loamy Ground Moraines 5.0
3 Alluvium, Kames, Outwash, and Valley Trains 4.0
4 Gently Rolling Silt Mantled Ground Moraine 11.0
5 Clay Mantled Ground Moraine 18.0
6 Broad Summit Clayey Mantled Moraines 3.0
7 Undulating Ground Moraine 9.0
8 Broad Summit Loamy Mantled Moraines 10.0
9a Gently Rolling 25.7
9b Rolling 3.0
9c Strongly Rolling 0.3
Irregular Loamy Ground, End, and Terminal Moraines
10 Clayey Glacial Lake Basin 6.0
11 Silty Glacial Lake Basin 4.0
BASE LEGEND
BASIN BOUNDARY
STATE BOUNDARY
COUNTY BOUNDARY
DRAINAGE
LAKE
MINNESOTA
N
BROWN
LE SUEUR
COTTONWOOD
WATONWAN
BLUE EARTH
WASECA
STEELE
JACKSON
MARTIN
FARIBAULT
FREEBORN
EMMET
KOSSUTH
WINNEBAGO
MINNESOTA
IOWA
MINNESOTA RIVER
LE SUEUR RIVER
BLUE EARTH RIVER
WATONWAN RIVER
COBB RIVER
MAPLE RIVER
ELM CREEK
CHAIN OF LAKES
EAST CHAIN
FOX LAKE
CENTER CREEK
LAKE HANSKA
EAGLE LAKE
MADISON LAKE
LAKE ELYSIAN
BUFFALO LAKE
LURA LAKE
MINNESOTA LAKE
RICE LAKE
FREEBORN LAKE
95°00'
93°30'
44°00'
43°15'
SCALE 1/500,000
SCALE 5 0 5 10 15 MILES
SOURCE:
AMS 1/250,000 TOPOGRAPHIC MAPS, MINNESOTA AND IOWA COUNTY HIGHWAY MAPS AND INFORMATION FROM THE FIELD TECHNICIANS.
TRANSVERSE MERCATOR PROJECTION
5,S-29,827

APPENDIX #3

INVENTORY FORMS

PROBLEMS AND NEEDS
QUESTIONNAIRE

These two worksheets were used by the Soil Conservation Service to gather information in the Blue Earth River Subbasin.

The Inventory Form, MN-RB-1 is used by the Soil Conservation Service to inventory technical data utilizing the knowledge and experience of District Conservationists, Extension Specialists, ASCS managers and other specialists within each county.

The Problems and Needs Questionaire was completed by each County Board of Commissioner and each Soil and Water Conservation District located in the Blue Earth River Subbasin.

MN-RB-1
7-70
(File Code RB-1)

SOUTHERN MINNESOTA RIVERS BASIN
INVENTORY FORMS

County________________

Date________________

Purpose and Instructions

The accompanying forms are to provide information needed for the Type IV study of the Southern Minnesota Rivers Basin, Phase I. This inventory will supplement data previously collected in CNI and other reports. The forms are intended for use on a county or district basis to make communications between the River Basin Staff and District Conservationists easier. Watershed units selected in Phase I will be studied in detail as Phase II.

Each form contains such instructions as deemed necessary. Three sets of maps will be used. The Inventory Map is a copy of the CNI watershed map. The Land Use Map and Drainage Map are each smaller scale district maps. Please direct questions to members of the River Basin Staff.

SOUTHERN MINNESOTA RIVERS BASIN
INVENTORY FORMS

County ______________

Land Use Appraisal

1. Locate on Land Use Map areas predominantly used for: Color Code

   a. High intensity, cash crop framing such as sweet corn peas, sod, potatoes, etc. Red

   b. Dairy farming Brown

   c. Pasture, range, hayland Green

   d. Forestland Black

   e. Cash grain production, i.e., wheat, soybeans Yellow

   f. Grain-livestock production Blue

2. Is there a trend of agricultural land changing to non-agricultural uses such as urban expansion, parks and roads?__________ If so, approximately how many net acres per year are changing from agricultural to non-agricultural uses__________________________.

3. Is floodplain land farmed as intensively as flood free upland areas?

   ____

   ____.

SOUTHERN MINNESOTA RIVERS BASIN
INVENTORY FORMS

County________________

Land Treatment Appraisal

1. Estimate total acres of cropland for the basin in your county____________.

2. Estimate total acres of cropland needing land treatment________________.

3. How many acres of cropland do you expect to be adequately treated 1/ by 1980? By 2020?

Year	Acres of Cropland that will be treated by:				
	Residue-minimum Tillage Ac.	Contouring Ac.	Stripping Terracing Diversions Ac.	Permanent Cover Ac.	Drainage Ac.
1980					
2020					

4. Estimate total acres of pasture for the basin in your county____________.

5. Estimate total acres of pasture needing land treatment________________.

6. How many acres of pasture do you expect to be adequately treated 1/ by 1980? By 2020?

Year	Acres of Pasture that will be treated by:			
	Protection from Overgrazing	Improvement of present Plant cover	Reestablish Vegetative Cover	Brush Control
1980				
2020				

7. Estimate the number of cropland acres presently:

   a. Adequately drained________________.

   b. Partially drained________________.

   c. Needing drainage but no measures installed____________________.

1/ Assume present rate of application.

SOUTHERN MINNESOTA RIVERS BASIN
INVENTORY FORMS

Flood Water Damage Appraisal

1. Outline on the county Inventory Map areas which you consider to be critical flood damage areas that should definitely be studied in more detail. These will generally be large floodplain areas which are primarily in cropland that flood frequently during the growing season. Consider all floodplains except the Minnesota River main floodplain.

   Outline the areas with green pencil and record the following information on the map adjacent to the outlined area.

   a. The maximum floodplain area (acres).

   b. The estimated percent of cropland, pasture and other land use on the floodplain.
      Crop (C), Pasture (P), Other (O).

   c. The estimated frequency of floods which cause some damage during the growing season. If the frequency is variable within a damage reach, record the frequency of flooding on the major damage area.

   d. The date of occurrence and the monetary damage caused by any known large flood events. Include all damages to crops, fences, roads, bridges, etc. This information may come from newspapers or special flood reports.
      Example: July 4, 1960, $80,000.

2. Outline on the county Inventory Map areas which receive major damage from sediment or floodplain scour. Consider large areas that are critical problem areas in the county. Outline these areas with orange pencil and record the acres damaged by a large flood adjacent to the outlined area on the map. Indicate whether the damage occurs from sediment or floodplain scour. Example: 500 Ac. scour.

SOUTHERN MINNESOTA RIVERS BASIN
INVENTORY FORMS

County ____________________

Drainage Problem Appraisal

1. On the Drainage Map outline areas with existing drainage conditions in these categories (do not overlap areas):

   a. Land does not normally need drainage - leave blank.

   b. Land is wetland which should remain undrained - label "W".

   c. Land having drainage needs that can be solved with on-farm measures - label "OF".

   d. Land having drainage needs that require small group action - label "SG".

   e. Land having drainage needs that are major problems and will require watershed type action for solution - label "MP".

2. For each of the above categories enter the estimated total acres in the county:

   a. ________________ acres   d. ________________ acres

   b. ________________ acres   e. ________________ acres

   c. ________________ acres

   Explain any definite action now planned for areas included in category d or e above:

3. Transfer to the Inventory Map those areas in category e which you feel should definitely be studied in detail. Outline in blue pencil.

SOUTHERN MINNESOTA RIVERS BASIN
INVENTORY FORMS

County________________

Present Irrigation Appraisal

Watershed (CNI No.)					Co. Total
Acres Irrigated Number of Farms Source of Water Crops Irrigated					

Water Source Code: W - well
P - pond
L - lake
S - stream
O - other

Remarks: (Describe any non-agricultural applications such as golf courses)

SOUTHERN MINNESOTA RIVERS BASIN
INVENTORY FORMS

County____________________

Water Supply Appraisal

1. List any water supply deficiency that presently exists or that you expect to exist in the near future.

   a. Agricultural (livestock or rural domestic).

   Location: Section____________________ Township______________

   Description of problem or need:____________________________

   ____

   ____.

   b. Non-agricultural (municipal or industrial).

   Name of community or industry______________________________

   Location: Section____________________ Township______________

   Description of problem or need:____________________________

   ____

   ____.

2. List any community or industry that presently depends on surface water for supply.

   a. Community____________________ Number of people____________

   Source of supply____

   b. Industry name____

   Location: Section____________________ Township______________

   Estimated use________________________ gallons per day

   Source of supply____

SOUTHERN MINNESOTA RIVERS BASIN
INVENTORY FORMS

County__________________

Water Quality Appraisal

1. Ground Water Quality - List any locality that has poor groundwater quality, describe the problem and comment on the interest and possibility of improvement.

   a. Agricultural (livestock or rural domestic).

   Location: Section______________________ Township______________

   Comments:____

   ____

   ____

   b. Non-agricultural (municipal and industrial).

   Name of community or industry________________________________

   Location: Section______________________ Township______________

   Comments:____

   ____

   ____

2. Surface Water Quality - List any lakes or streams that are polluted to the degree that they are losing their aesthetic value or are becoming unsuitable for recreation use. Make comments on the major sources of pollution such as municipal wastes, industrial wastes, livestock wastes, pesticides or fertilizers, sediment, shoreline development wastes, etc. Comment also on the interest in pollution abatement and what is being done (if anything) to solve the problem.

   Name of lake:____

   Location: Section______________________ Township______________

   Name of stream:______________________________ Polluted reach from

   Section______________________________ Township______________

   to Section____________________________ Township______________

   Comments:____

   ____

   ____

PROBLEMS AND NEED QUESTIONAIRE
Blue Earth River Basin

This questionaire is a worksheet to be used by the Soil Conservation Service, River Basin Staff, for informal data gathering from local interested citizens and groups. It will assist the U. S. Department of Agriculture in the study of the Blue Earth River Basin. Please confine your remarks to areas within the Blue Earth Basin.

This questionaire will be kept confidential, however we need your name and address so that we know the source of the information and so we may contact you if questions arise or further information is needed.

County ________________ Name of person ________________________

Address ________________ Representing ________________________

A. Following is a list of the areas of study that relate to the general problems and needs of the Blue Earth Basin. Please number, in the order of importance, the study areas that need the most emphasis in your county.

____ Flood protection ______ Drainage improvement ____ Irrigation potential

_____ Recreation development _____ Fish and wildlife development

_____ Pollution control _____ Erosion and sediment control

_____ Municipal and industrial water supply ____ Lake level regulation

_____ Flood plain management ____ (Other)______________________

B. List in the order of importance the watersheds that have the most flood damage and list the areas where the major damage occurs.

Watershed, Stream Name or Ditch Number	Sections, Twps	Remarks
1.		
2.		
3.		
4.		
5.		

PROBLEMS AND NEED QUESTIONAIRE
Blue Earth River Basin

C. List in the order of importance the watersheds where drainage is not adequate and list the areas where the major problem occurs.

Watershed, Stream Name or Ditch Number	Sections, Twps	Remarks
1. ______	______	______
2. ______	______	______
3. ______	______	______
4. ______	______	______
5. ______	______	______

D. If you feel that priorities of study for flood protection or drainage improvement are needed for certain areas, list the priority below.

Watershed, Stream Name or Ditch No.	Remarks
1. ______	______
2. ______	______
3. ______	______
4. ______	______
5. ______	______

E. Generally is the present legal ditch system in your county:

1. Adequate ______ Remarks ______

2. Not adequate but is being improved at a satisfactory rate ______

   Remarks ______

3. Not adequate and needs improvement at an accelerated rate under present legal ditch procedure______

   Remarks ______

4. Not adequate and need other methods of solving drainage problems___

   Remarks ______

PROBLEMS AND NEED QUESTIONAIRE
Blue Earth River Basin

F. Is there interest among farmers in your county for development or expansion of irrigation systems?

1. Yes ____ a. Interest in townships ________, ________, ________

b. On what crops? ________, ________, ________,________

No _____ Because:

a. No areas of droughty soils ____________

b. Limited or costly water supply ____________

c. Equipment or labor cost too high for return ________

d. Other ____________________

G. List any existing lakes that you feel should be improved for recreation or other use and the type of improvement needed.

Name of Lake	Improvement Needed
1. ________	____ Larger surface area _____ More depth ____ Public access
	____ Improved water quality _____ Other ____________
2. ________	____ Larger surface area _____ More depth ____ Public access
	____ Improved water quality _____ Other ____________
3. ________	____ Larger surface area _____ More depth ____ Public access
	____ Improved water quality ____ Other ____________
4. ________	____ Larger surface area _____ More depth ____ Public access
	____ Improved water quality ____ Other ____________

H. List any areas that are not now public land that you feel should be purchased and developed for wildlife or recreation use. Indicate what level of government should purchase and maintain each area. ie. city, county, state, federal.

Location	Type of Development	Suggested Ownership
1. Sec___ Twp ____	____________	____________
2. Sec___ Twp ____	____________	____________

PROBLEMS AND NEED QUESTIONAIRE
Blue Earth River Basin

Location	Type of Development	Suggested Ownership
3. Sec___ Twp___	___	___
4. Sec___ Twp___	___	___

I. Do you favor purchase of floodplains along major streams for development of environmental corridors?

Yes ___ No ___ Remarks ___

___

J. List any stream reaches that you feel should be purchased and developed for canoe trails, nature trails or environmental corridors.

Stream Name	Location	Type of Development
1. ___	From Sec ___, ___ Twp	___
___	To Sec ___, ___ Twp	___
2. ___	From Sec ___, ___ Twp	___
___	To Sec ___, ___ Twp	___
3. ___	From Sec ___, ___ Twp	___
___	To Sec ___, ___ Twp	___

K. Describe any potential developments of a commercial or industrial nature that would benefit the local economy if a specific water and related land area were improved or protected. Example: If recreation facilities and fishing conditions were improved on Mud Lake, tourists would add support to the economy of Mudville.

___

___

___

___

___

PROBLEMS AND NEED QUESTIONAIRE
Blue Earth River Basin

L. Do you feel that most farmers will accept the responsibility and a portion or all of the cost of controlling the runoff wastes from their land that contribute to the pollution of lakes and streams? _____ Remarks __________

____

M. Is part of the opposition to the Corps of Engineers proposed Blue Earth Dam due to the fact that farmers in your county believe that drainage outlets will be impaired? ________ Remarks ______________________________

____

N. Do you feel that people would not object to the proposed Blue Earth Dam if the dam could be lowered so that less cropland would be flooded upstream and Garden City would not be inundated? __________ Remarks _______

____

____

O. General Remarks:

____

____

____

____

____

____

____

____

____

____

____

APPENDIX #4

HYDROLOGIC MODEL STUDY

BLUE EARTH RIVER SUBBASIN

1. Downstream Effects of Upstream Projects

A. Introduction

It has become evident in the study of the Blue Earth Subbasin that the effects of alternative projects should be known to better evaluate both technical design considerations and the social implications from such projects. At this time, study results are limited to the hydraulic effects (not economic feasibility) of a potential system of upstream reservoirs. Two flood events were anlayzed to determine the hydraulic modification resulting from the structures. The two floods evaluated were the spring runoff floods in 1965 and 1969. Storage of floodwaters was assumed to be accomplished with structures that:

(1) Meet the design criteria for structures normally constructed in the SCS small watershed program (PL 566).
(2) Meet the design criteria for structures normally constructed in the SCS conservation program (PL 46).

Most sites considered have at least five square miles of drainage area and 2-4 inches of available flood storage.

B. Methodology

The purpose of storing floodwater is to protect an area from flood damage. The cost of protecting a flood damage area may be quite variable. Generally, the closer the flood storage area can be placed upstream from the damage area the more effective and inexpensive the control costs. To protect a city with a drainage area of 5,000 square miles would require designing for different storm patterns, amounts of runoff and time distribution than a 50 square mile agricultural watershed. To make compatible studies for upstream and downstream areas, a hydrologic mathematical model of the Blue Earth Subbasin was developed. Hydrologic studies of the subbasin conditions during the flood occurrence and the resulting runoff were compared to the USGS stream gage records to determine validity of results.

The hydrologic model was developed using the USDA Soil Conservation Service Technical Release 20 - Computer Program for Project Formulation - Hydrology. Peak discharge and time distribution of the resulting hydrographs were checked at the Rapidan Gage on the Blue Earth River (2400 sq. miles) and at Bricelyn (132 sq. miles). Miscellaneous readings were also checked. Duplication of the storms studied was determined to be realistic and the routings were considered adequate for the simulation of the flood events.

The subbasin model considers the upstream hydraulics and is set up to reflect the effect of small upstream reservoirs and existing lakes and sloughs. Refined and detailed studies of specific projects were included in the subbasin model. There is one PL 566 watershed, Upper Watonwan River, that is presently being planned. Preliminary design data was used for this watershed in the subbasin model.

C. Results

(1) Model results compared to natural conditions:

Snowmelt runoff floods are difficult to reconstruct. There is seldom sufficient data in the detail desired to exactly duplicate the actual hydrologic conditions. Weather Bureau information on water content in snow, temperature of soil and air, and SCS information on soils and cover were used in calculating the runoff of the floods and compared with USGS stream gage runoff volume.

(2) 1965 Spring Flood

The first runoff distribution study was made using generalized subbasin data. The second attempt came from a detailed study of the water records in the subbasin and in southern Minnesota, northern Iowa and South Dakota. This study gave the proper runoff volume. The third attempt gave a realistic snowmelt distribution that duplicated the hydrographs at the stream gages.

The spring flood of 1965 occurred April 1-20th and produced the largest recorded peak discharge (43,000 cfs) on the Blue Earth River at the Rapidan stream gage with a total runoff volume of 5.2 inches from the watershed in a 20 day period. The peak discharge rate from the approximately 2400 square miles was 18 cubic feet per second per square mile (csm). The 875 square miles in the Watonwan River Watershed produced 30 csm peak discharge and the 1450 square miles in the Blue Earth River portion of the subbasin discharged a maximum of 19 csm. Some of the watersheds with less than 5 square miles drainage area produced more than 40 csm while others with lakes and swamps had less than 10 csm peak outflow. The study in the LeSueur River Watershed is not complete but the stream gage (at 1100 square miles) indicated 22.5 csm or 24,700 cfs. The 1965 flood was approximately a 60 year frequency event at the mouth of the Blue Earth River. The runoff was not equally distributed in the watershed nor did it run off at the same rate or time. In the 20 day runoff period the Blue Earth River contributed 2.9 inches of runoff and the Watonwan River released 2.3 inches of the 5.2 inches total runoff.

The peak discharges were caused by runoff during the first 10 days of rain and snowmelt. The last 10 days of runoff came from tile and return flow from the soil. This base flow was approximately 1/10 inch per day from the drainage area. Runoff in the basin occurred under the soil cover complex curve number 94. This was computed from the 20 day stream gage volume and the composite subbasin precipitation (snow water content and rainfall). The curve number and the cumulative daily precipitation was used to determine daily runoff volume. The base flow from soil and depressional storage was computed to be 2 inches from the gaged hydrograph at Rapidan. The upstream structures reduced the peak discharge at the Rapidan Dam by 12%. Storage in the Rapidan Dam was not considered in the model.

(3) 1969 Spring Flood

The 1969 flood was caused almost entirely from snowmelt runoff. The peak discharge on the Blue Earth River at the stream gage near Rapidan was 21,100 cfs or approximately 9 csm. The peak discharge on the LeSueur River was 10,900 cfs or 10 csm. The snowmelt period was extended over approximately 20 days, twelve days in March and eight days in April. The 40 day runoff on the Blue Earth River at Rapidan was approximately 5.2 inches. The moisture content in the snow and precipitation during this period was 8.9 inches. This indicates a runoff curve number of 70 for the extended period. A 2.7 inch runoff from the March snowmelt produced a base flow of 5800 cfs in April on the Blue Earth River at Rapidan. This base flow, added to the routed peak discharge from snowmelt, reproduced the peak discharge at the Rapidan gage.

The 1969 flood was of intermediate severity. It was approximately an 8 year frequency occurrence on the Blue Earth River near Rapidan and caused little damage in the watershed but produced long periods of outflow. The 5800 cfs base flow discharge was nearly a 2 year frequency occurrence by itself.

The upstream structures in the Blue Earth and Watonwan River Watershed reduced the peak discharge of the 1969 flood on the Blue Earth River near Rapidan by about 4 percent and delayed the peak discharge by one day.

(4) The 1965 and 1969 spring floods both had about 5.2 inches of runoff. The melt rate was of two extremes which allowed a good comparison of the effect of upstream reservoirs under different conditions.